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IRON AND STEEL ENGINEER

AUGUST • 1939

VOL. XVI NO. VIII

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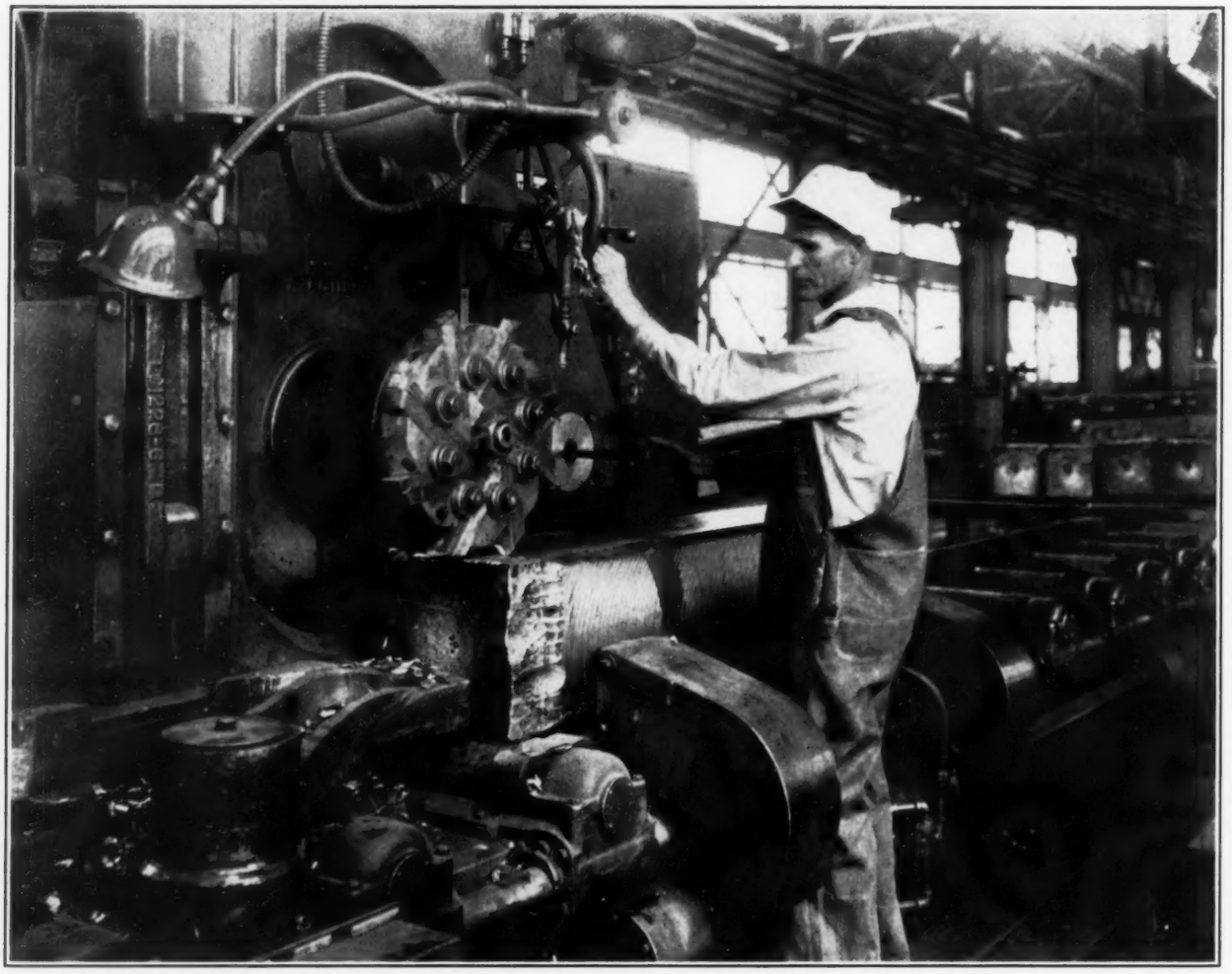

Photo showing eight-tool cutting head of Bonnot-Lentz Billeteer. This is one of several Billeteers which are in operation 24 hours per day in the plant of The International Nickel Company, Huntington, West Virginia.

STEEL EQUIPMENT DIVISION

THE BONNOT COMPANY

CANTON OHIO U.S.A.

35th

ANNUAL CONVENTION

and IRON AND STEEL EXPOSITION

ASSOCIATION OF IRON AND STEEL ENGINEERS

Pittsburgh

WILLIAM PENN HOTEL, PITTSBURGH, PA.

Tentative Program

SEPTEMBER 26 - 27 - 28 - 29, 1939

All ACTIVITIES

Tuesday, September 26

Iron and Steel Exposition—9:00 A. M.—10:00 P. M.

9:00 A. M.—*Registration*—Main Lobby

Chairman	*Vice Chairman*
Freeman H. Dyke Superintendent, Blooming, Bar and Hot Strip Mills, Wheeling Steel Corporation Steubenville, Ohio	L. V. Black Electrical Superintendent, Bethlehem Steel Company, Bethlehem, Pennsylvania

9:15 A. M.—BUSINESS SESSION—Forum Room

Chairman	*Vice Chairman*
C. C. Wales Cleveland, Ohio	J. L. Miller, Assistant Chief Combustion Engineer, Republic Steel Corporation, Cleveland, Ohio

9:30 A. M.—ELECTRICAL ENGINEERING DIVISION—Forum Room

Chairman	*Vice Chairman*
W. A. Perry Superintendent, Electrical and Power Departments, Inland Steel Company, Indiana Harbor, Indiana	I. N. Tull Electrical Superintendent, Republic Steel Corporation, Cleveland, Ohio

"*A Double Bus System for Power Transmission*", by D. I. Bohn, Electrical Engineer, Aluminum Company of America, Pittsburgh, Pennsylvania, and J. E. Housley, Superintendent of Power, Aluminum Company of America, Alcoa, Tennessee.

"*Vacuum Tube Control for Steel Mill Applications*", by H. L. Palmer, Electronic Section, and H. W. Poole, Steel Mill Section, General Electric Company, Schenectady, New York.

"*The Transition from 25 to 60 Cycle Power in the Steel Industry*", by W. B. Skinkle, Secretary and Engineer, Pittsburgh District Power Committee, United States Steel Corporation Subsidiary Companies, Pittsburgh, Pennsylvania.

12:30 P. M.—*Ladies' Luncheon Bridge*

1:30 P. M.—MECHANICAL ENGINEERING DIVISION—Forum Room

Chairman	*Vice Chairman*
C. J. Duby Chief Engineer, Youngstown and Warren Districts, Republic Steel Corporation, Youngstown, Ohio	J. D. Jones Chief Engineer, Youngstown Sheet & Tube Company, Youngstown, Ohio

"*Economics of Advanced Engineering Planning*", by A. R. Schulze, Chief Engineer, Carnegie-Illinois Steel Corporation, Youngstown, Ohio.

"*Modernization of Existing Open Hearth Furnaces and Auxiliary Equipment*", by G. L. Danforth, Jr., Open Hearth Combustion Company, Chicago, Illinois.

"*Developments in Rolling Flat Steel Products—1939*", by Stephen Badlam, Consulting Engineer, Pittsburgh, Pennsylvania.

1:30 P. M.—WELDING ENGINEERING DIVISION—Club Floor Parlor

Chairman	*Vice Chairman*
A. W. Steed Maintenance Superintendent, American Rolling Mill Company, Middletown, Ohio	E. W. Trexler Maintenance Superintendent, Bethlehem Steel Company, Johnstown, Pennsylvania

"*Stress Relief in Welded Structures*", by Dr. J. C. Hodge, Chief Metallurgist, Babcock & Wilcox Company, Barberton, Ohio.

"*The Welding of Rail Ends and Joints of Crane Runways*", by Wray Dudley, Assistant Superintendent of Maintenance, National Tube Company, McKeesport, Pennsylvania.

"*Welding Electrodes and Their Applications*", by J. H. Deppler, Chief Engineer, Metal and Thermit Corporation, New York, New York.

"*Automatic Atomic Hydrogen Welding of Steel*", by J. T. Catlett, General Electric Company, Schenectady, New York.

10:00 P. M.—EXHIBITORS' DANCE—Informal—Cardinal Room

Wednesday, September 27

Iron and Steel Exposition—9:00 A. M.—10:00 P. M.

9:00 A. M.—OPERATING PRACTICE DIVISION—Cardinal Room

Chairman	*Vice Chairman*
H. G. R. Bennett Assistant General Superintendent, Carnegie-Illinois Steel Corporation, Duquesne, Pennsylvania	W. C. McConnell Plant Superintendent, Republic Steel Corporation, Massillon, Ohio

Symposium on the Preparation of Steel for Subsequent Rolling:

"*Preparation of Semi-finished Steel*", by A. P. Spooner, Metallurgical Engineer, Bethlehem Steel Company, Bethlehem, Pennsylvania.

UNDER One ROOF

"*Mechanical Billet Chipping*", by G. W. Lentz, Chief Engineer, Bonnot Company, Canton, Ohio.

"*Steel Conditioning with the Oxy-acetylene Method*", by G. D. Winlack, Air Reduction Sales Company, New York, New York.

"*Billet Grinding*", by A. Rousseau, Norton Company, Worcester, Massachusetts.

12:45 P. M.—*Inspection Trip*: 80 in. Hot and Cold Strip Mills, Irvin Works, Carnegie-Illinois Steel Corporation, Dravosburg, Pennsylvania.

2:00 P. M.—*Ladies' Sight-seeing Trip.*

Thursday, September 28

Iron and Steel Exposition—9:00 A. M.—5:30 P. M.

9:00 A. M.—ELECTRICAL ENGINEERING DIVISION—Cardinal Room

Chairman	*Vice Chairman*
K. E. Dinius Electrical Superintendent, Carnegie-Illinois Steel Corporation, South Chicago, Illinois	L. R. Milburn Electrical Engineer, Great Lakes Steel Corporation, Ecorse, Michigan

"*Gauge Control for Cold Strip Mills*", by F. Mohler, Electrical Engineer, Steel Mill Section, General Electric Company, Schenectady, New York.

"*Power Requirements of Cold Strip Mills*", by A. F. Kenyon, Steel Mill Engineer, Industrial Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

"*Development in Electrical Truck Transportation in Continuous Sheet and Strip Mills*", by C. B. Crockett, Industrial Truck Statistical Association, Chicago, Illinois.

9:00 A. M.—COMBUSTION ENGINEERING DIVISION—Forum Room

Chairman	*Vice Chairman*
G. M. Coughlin Combustion Engineer, American Rolling Mill Company, Ashland, Kentucky	P. F. Kinyoun Combustion Engineer, Bethlehem Steel Company, Lackawanna, New York

"*Types and Selection of Refractories for the Steel Plant*", by J. S. McDowell and J. P. Bankson, Harbison-Walker Refractories Company, Pittsburgh, Pennsylvania.

"*Observations on the Heating of Steels from the Metallurgical Viewpoint*", by E. E. Callinan, Combustion Engineer, and Gilbert Soler, Director of Research, Steel and Tube Division, Timken Roller Bearing Company, Canton, Ohio.

"*Modern Gas-Mixing Systems as Applied to Steel Plant Requirements*", by G. M. Arnold, Cutler-Hammer, Inc., Chicago, Illinois.

1:30 P. M.—OPERATING PRACTICE DIVISION—Forum Room

Chairman	*Vice Chairman*
J. G. West, Jr. District Superintendent, Blast Furnace and Coke Ovens, Youngstown Sheet and Tube Company, East Chicago, Indiana	A. H. Fosdick Superintendent Blast Furnace and Sintering Plant, Bethlem Steel Company, Bethlehem, Pennsylvania

"*Yields of Coke and By-Products from Various Coals*", by J. D. Davis, Supervising Chemist, Coal Carbonization Section, Bureau of Mines, Pittsburgh, Pennsylvania.

"*Reasons for Adopting Certain Details in the Design of the New Inland Blast Furnace*", by H. W. Johnson, Superintendent of Blast Furnaces, Inland Steel Company, East Chicago, Indiana.

"*Reconstructed Blast Furnace Shell of Welded Design*", L. J. Gould, Assistant Chief Engineer of Construction, Bethlehem Steel Company, Bethlehem, Pennsylvania.

1:30 P. M.—LUBRICATION ENGINEERING DIVISION—Cardinal Room

Chairman	*Vice Chairman*
F. L. Gray Lubrication Engineer, Carnegie-Illinois Steel Corporation, Gary, Indiana	T. R. Moxley General Master Mechanic, Wheeling Steel Corporation, Steubenville, Ohio

"*Modern Lubrication of Existing Equipment*", by F. J. Thomas, Lubrication Engineer, Republic Steel Corporation, Cleveland, Ohio.

"*Progress of Lubrication in the Steel Mills*", by C. C. Pecu, Lubrication Engineer, Bethlehem Steel Company, Lackawanna, New York.

"*Causes of Gear Wear and Failure*", by J. H. Jones, Metallurgist, Republic Steel Corporation, Massillon, Ohio.

7:00 P. M.—FORMAL BANQUET AND DANCE

Speakers: B. F. Fairless, President, United States Steel Corporation, Pittsburgh, Pennsylvania

Strickland Gillilan

Friday, September 29

Iron and Steel Exposition—10:00 A. M.—3:00 P. M.

9:00 A. M.—*Inspection Trip*: Edgar Thomson Works, Carnegie-Illinois Steel Corporation, Braddock, Pennsylvania.

Iron & Steel Exposition

SPONSORED BY

ASSOCIATION OF IRON AND STEEL ENGINEERS

WILLIAN PENN HOTEL - PITTSBURGH, PENNA.

SEPTEMBER 26 - 27 - 28 - 29, 1939

PRESENTING the latest developments in the products of over 100 manufacturers of steel plant equipment, the annual Iron and Steel Exposition, held in conjunction with the annual Convention of the Association of Iron and Steel Engineers, offers much of interest to engineering and operating men of the iron and steel industry.

Utilizing 20,000 sq. ft. of space, the exhibits offer a complete cross-section of the engineering applications in the industry and will prove of universal appeal to those who desire to keep abreast of the new improvements. The Exposition will be held in the Wm. Penn Hotel, in close proximity to the technical sessions and other activities of the Convention. This placing of all activities under one roof facilitates complete participation in all Convention activities.

EXPOSITION HOURS

TUESDAY, SEPT. 26—9:00 A. M. to 10:00 P. M.
WEDNESDAY, SEPT. 27—9:00 A. M. to 10:00 P. M.
THURSDAY, SEPT. 28—9:00 A. M. to 5:30 P. M.
FRIDAY, SEPT. 29—9:00 A. M. to 3:00 P. M.

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Review of

Presented before A. I. & S. E. Pittsburgh-Cleveland District Sections at Youngstown, Ohio, May 2, 1939

By CARL OHLSON, *General Manager*,
AETNA-STANDARD ENGINEERING COMPANY,
YOUNGSTOWN, OHIO

▲ REACHING back to the very beginning of civilization when human beings first established themselves in communities, the need for pipes has existed. For instance, transportation of water for various purposes was very early done by means of pipes which were made from bamboo or from hollow logs. In Egypt earthenware pipes were used thousands of years ago, and the Romans made crude lead and bronze tubing. In 1685 cast iron water pipes were made, and sometime earlier, gun barrels were made by bending into cylindrical form a flat piece of iron or steel, overlapping and welding the edges together.

As civilization progressed, the need for pipes and tubes increased, particularly when, in the early years of the nineteenth century, the use of artificial gas was introduced for the purpose of lighting. About the same time progress was being made in both the lap weld and butt weld processes. In 1825, Cornelius Whitehouse succeeded in making a commercially satisfactory pipe by drawing a heated flat piece of iron through a conical die or bell, and thereby laying the foundation of the present day butt weld practice.

After these developments had taken place, and the need of stronger and more dependable tubing became evident, attention was turned towards production of seamless steel tubes. The first attempts were made along the lines already used in making lead and bronze tubing; that is, by extruding the hot metal through a circular die of a diameter corresponding to the outside diameter, and in the center of which had been placed a supported plug of a diameter equal to the desired inside diameter of the tube. These attempts failed primarily on account of absence of die and plug material which could withstand the temperature of the heated steel. It is our understanding that during the last few years, this method has been revived to some extent in Europe, the improved results being attained through the development of high temperature resisting material for dies and plugs.

Tube manufacture by the cupping process was patented by Redmond in 1851. In the cupping process a circular plate is forced by successive operations through a series of dies, each succeeding pair being deeper than the preceding pair, until the plate takes the shape of a cylinder with one end closed. The process was intended to make all sizes of tubing, but at the time was not commercially successful on account of inability to produce sufficiently long tubes. This process is still in use, principally for sizes 5 in. and larger in comparatively short lengths such as required for gas cylinders, couplings and so forth.

About this time some seamless tubes were also being produced from cylindrical billets by drilling a hole through the center thereof, heating the billet and en-

DEVELOPMENTS *in* *Seamless Tube* MANUFACTURE

Close-up of piercing mill, a heavily designed unit in which the billet is rough pierced for subsequent rolling.

enlarging the hole by rolling over successively larger mandrels. After this, the blank was again heated and the outside diameter and wall thickness reduced by rolling on a mandrel through successively smaller grooves.

In the absence of a more practical and economical process, the manufacture of seamless tubing was restricted for several decades. However, beginning with 1885 it received its real impetus by the invention of the Mannesmann Brothers of the most widely used method of producing seamless tubes; that is, by piercing a solid round between oblique rolls. This invention proved of enormous magnitude and therefore we believe it to be of interest to relate some of the circumstances and incidents leading up thereto.

At Remsheid in Germany, the Mannesmann family operated a crucible steel plant and a file factory. In working the steel down to the desired sizes, it was found that unless particular care was taken in the forging operation, the center of the forged bar would show signs of rupture. This condition was also in evidence in "reeled" rounds; that is, rounds that had been sized and polished on rotary rolling. Investigation showed that signs of rupture were more noticeable in bars that had been reduced perceptibly in size by the reeling operation.

The Mannesmann firm also produced what at that time was termed a "compound" steel; that is, steel having a hard outside layer around a soft center. This material enjoyed a wide use for axles, piston rods, and other articles subjected to wear. It was found that in forging down this material a uniform thickness of the hard layer could not be maintained consistently. It was suggested that the desired results could be attained by rotary rolling, and a mill was built at Remsheid along the lines of the reeling machines already in use for round bars.

The product from this mill showed a uniform thickness of the hard layer, but it also showed a decided tendency to rupture in the center as had already been observed in reeled or severely forged bars, and the mill therefore was not a success for the intended purpose.

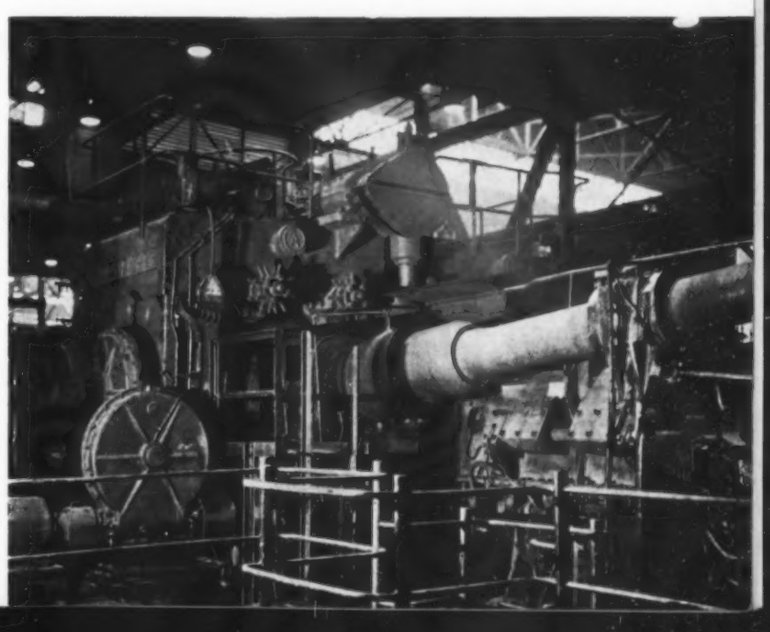
It did, however, give the Mannesmann brothers the idea that an apparatus could be designed, which, with greater deformation of the bar, and with the proper obliquity and contour of rolls, would cause complete rupture of the center throughout the full length of the bar, and thereby produce a seamless tube.

Acting upon this idea, they conducted their first experiments in 1884. The first billets used for these experiments were only 1 in. to 1¼ in. diameter x 20 in. long.

Their experiments were promising, and the first piercing process patent appeared the 27th of January, 1885, and on the 22nd of August, 1886, the inventors were able to produce their first tube, or rather pierced billet. Between that time and 1890 a great many experiments were made with various roll types, roll contours, and various positions of mandrel in relation to the rolls, until finally piercing could be done in a satisfactory manner.

However, efforts to produce tubing of sufficiently thin wall failed, and the pierced billets, usually after

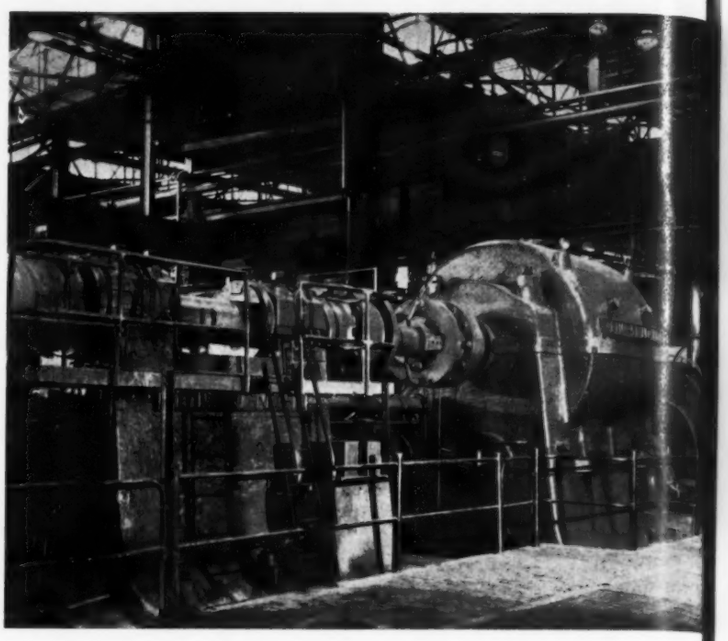
Rear view of piercing unit, showing drive spindle. This piercer is driven by a 5000 hp., 6600 volt, 360 rpm. synchronous motor.



reheating, had to be reduced to the desired size by rolling on a mandrel in a bar mill in the already existing manner. This method of producing tubes of commercial wall thickness was not entirely satisfactory. Search for a more suitable process led to the invention of the Pilger mill to which reference will be made later on.

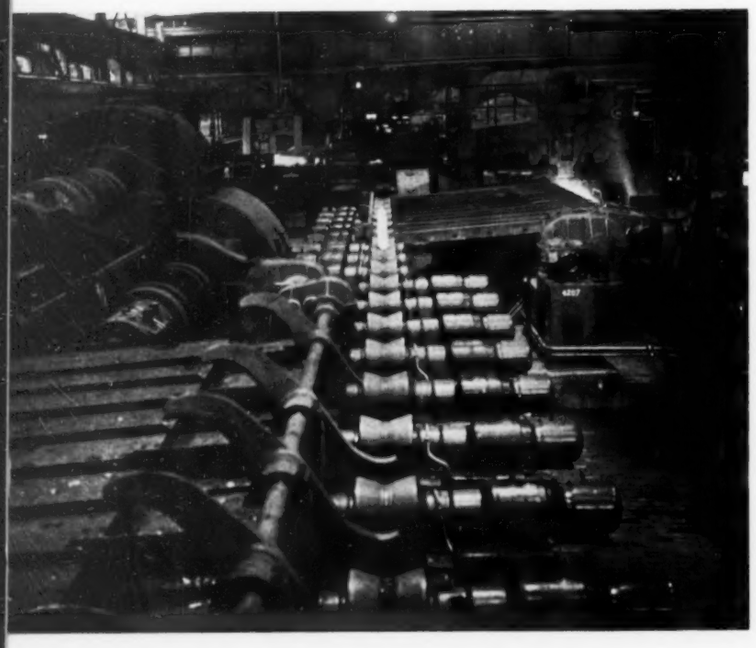
Prior to 1896 seamless tubes had been produced in this country by cold drawing from imported pierced billets, or by the cupping process. In that year Stiefel designed and installed at Ellwood City, Pennsylvania, a mill consisting of a Stiefel disc piercer, two Pilger mills, a machine for reeling off mandrels and a mandrel extractor. It was capable of producing tubes up to 2¼ in. diameter. The first mill was followed in 1899 by another also designed and installed by Stiefel at Ellwood City, this second mill having practically the same arrangement except that it was equipped with a conical roll piercer. In 1906 Stiefel brought out the modern plug rolling mill with rapid lift of the top roll and rapid return rolls, and the 1899 mill was rebuilt with disc piercer, new plug mill, two reelers and a sizing machine. The rebuilt mill was designed to make maximum size tubes of 4½ in. outside diameter x 20 to 25 ft. long, but about 1910 some 6⅝ in. outside diameter tubes were made, this being the maximum size produced by the automatic type mill up to that time.

In 1923 a 34 in. x 20 in. piercer was built. It was driven by a 2000 hp. motor at 100 rpm. The automatic plug mill had rolls 22 in. x 61½ in., and the installation was designed to make tubes up to and including 8⅝ in. outside diameter x 45 ft. long. In 1925 a 38 in. x 20 in. piercer driven by a 3000 hp. motor was installed for the purpose of making tubes 10¾ in. outside diameter by about 30 ft. long. To this mill a 51 in. diameter piercer driven by a 5000 hp. motor was added later on and by double piercing the upper range of sizes extended to 13⅜ in. outside diameter. The year 1929 saw installations of mills having double piercers capable of making 16 in. diameter tubes and equipped with expanding machines to finish tubes 24 in. and even 28 in. diameter.



View of double reduction gear unit through which the piercing unit is driven. The breaking spindle is shown next to the gear unit.

View of conveyor table used to move billets through the tube mill. Rollers are equipped with anti-friction bearings and driven by individual motors.



About fifteen years ago, two German-built Pilger mills were put into operation in this country, one at Youngstown Sheet and Tube Company and the other at Pittsburgh Steel Company. Both mills were designed to make tubes up to 13⅜ in. outside diameter, 60 to 80 ft. long. The Pilger mill was invented by Mannesmann and several patents were issued from 1890 to 1895. The first mill was installed at Komotau in 1892. (Incidentally, the German word "Pilger" means pilgrim and the name "Pilger" was chosen on account of the similarity between the motion of the work piece in the mill and the manner in which participants (pilgrims) in a certain ceremonial procession advanced toward their goal by taking some steps forward, then a lesser number of steps backwards and repeat.)

For use in the Pilger mill, a bottom-poured round ingot, some 2 in., 3 in. or even 4 in. larger in diameter than the outside diameter of the finished tube, are pierced to an inside diameter approximately the same

as the inside diameter of the finished tube, and therefore have a wall of considerable thickness. After piercing, the ingot is positioned in line with and between a feeding apparatus and the mill, and a mandrel inserted. A hydraulic cylinder, back of the ingot turning mechanism then pushes the turning mechanism, the mandrel, which is fastened thereto, and the ingot up to the bite of the rolls. The rotation of the rolls is opposite to the direction in which the work piece is being fed into the rolls (that is, looking at the mill from the side so that the rolls are to the right and the feeding mechanism to the left, the top roll runs clockwise and the bottom roll counter-clockwise.) The forming of the tube from the pierced ingot is really a forging process, which is done in one roll pass.

The pass in which this is done is an irregularly shaped tapered pass, eccentric with the roll necks except for the comparatively short part of the roll circumference which serves as the finishing pass, this part being concentric with the roll necks. The work piece is moved up to the rolls by means of the aforementioned hydraulic cylinder, and enters the big part of the pass, to be immediately pushed back by the action of the rolls working against it. The turning mechanism now turns the piece 90 degrees while returning it to the rolls, where it again enters the large part of the pass, only this time being advanced a little farther by means of the hydraulic cylinder. After a few blows, the front end of the piece has been forged out between the mandrel and the rolls until it reaches the part of the roll pass which is concentric with the roll necks and which has an opening corresponding to the outside diameter of the finished tube, and from which it emerges as a practically finished tube, a small length being added for each revolution of the rolls. In this manner the whole ingot is forged out, except the very last part, called the "pilger head". The mandrel is withdrawn, the top roll raised and the tube advanced to a saw which trims the front end and cuts off the pilger head. The tube is then put through a reheating furnace and given the final finish in a reeler.

The output of the Pilger mill is not very great when the magnitude and cost of the installation is considered, and partly on account of this the Youngstown Sheet and Tube Company in 1930 changed the method of operation by installing a reheating furnace and a 38 in. x 56 in. plug mill between the Pilger mill and the reelers. With this arrangement in which the Pilger mill was used as a breakdown mill only, the pilgering time was reduced, the tonnage materially increased, and improvement shown in appearance of outside surface.

The operating equipment of a Pilger mill, such as mandrels and rolls, is expensive both from standpoint of first cost as well as maintenance. This, and the inconvenience of making the required bottom-poured round ingots, and other reasons, prompted the Youngstown Sheet and Tube Company to eliminate the original German piercing mill and the two Pilger stands and in their place install two high speed piercing mills. These new piercing mills which were put in operation during February 1938, represent the latest and most powerful

The pierced tube blank passes to the high or plug mill, where it is rolled over a mandrel between grooved rolls.

Following the reelers is the sizing mill, the stands of which are inclined 45 degrees from the vertical in alternately opposite directions.

installation of its kind in the United States and in their construction have been incorporated improvements not present in earlier units.

The mills are served by two triple fired, side discharge, walking beam furnaces which are 83 ft. long and 25 ft. wide, each having a heating capacity of 50 gross tons per hour. Billet lengths are mainly 7½ to 11 ft. Should billets shorter than 7½ ft. be required, they can be heated in double length and divided by means of a gas cutting machine located in the furnace run out table. The mills are arranged for either double piercing or, by going direct to No. 2 piercer, for single piercing. The distance between the two piercers is 86 ft.–3 in. longitudinally and they are staggered 31 ft. laterally. The mills have a rated annual capacity of 300,000 tons and can handle the following:

Maximum size solid billet entering No. 1 piercer—13 in. dia. x 18 ft. long.

Maximum size pierced billet leaving No. 1 piercer—15 in. dia. x 26 ft. long.

Maximum size pierced billet entering No. 2 piercer—15 in. dia. x 26 ft. long.

Maximum size pierced billet leaving No. 2 piercer—18 in. dia. x 38 ft. long.

The piercing rolls are 51 in. maximum diameter with a barrel length of 30 in.

The two piercers are identical except for speed and direction of rotation. No. 1 piercer runs at 71.5 rpm. and No. 2 at 77 rpm., giving surface speeds of 955 and 1030 ft. per min. respectively with maximum roll diameters. Rolls in No. 1 piercer run counter-clockwise and in No. 2 clockwise when looking into the mill from the entry side. Obliquity of rolls can be adjusted up to 12 degrees.

Each roll is equipped with two roller bearings; the one on the free end is 18 in. inside diameter; 28¾ in. outside diameter by 16½ in. long and has a thrust load capacity of 300,000 lb. The bearing on the driven end has an inside diameter of 19¼ in. an outside diameter of 26 in. and a length of 16 in.

Each mill is driven by a 5000 hp. 360 rpm. synchronous motor. The helical gears have a circular pitch of about 2¼ in. x 32 in. face, and the shafts run in roller bearings. The drives were designed to take an overload of 100 per cent.

The main driving spindles are equipped with universal joints. They are 16 in. diameter x 19 ft.–7 in. long on the first piercer and 27 ft.–7 in. long on the second.

Length of the first inlet table is 19 ft.–6 in. to accommodate maximum billet length of 18 ft.–0 in. Air cylinder of the pusher is 7½ in. diameter x 17 ft.–0 in. stroke.

First outlet table is 27 ft.–0 in. long for 26 ft.–0 in. maximum length pierced billet. It is equipped with two roller type bar steadiers. Travel of thrust block carriage is 32 ft.–10 in. and the thrust block is equipped with roller bearings.

Clear length of the second inlet table is 27 ft.–6 in. and the pusher cylinder is 7½ in. diameter x 17 ft.–0 in. stroke.

Second outlet table is 39 ft.–0 in. long for 38 ft.–0 in. maximum length of pierced billet. Three bar steadiers are provided. Travel of thrust block carriage is 45 ft.–2 in.

Approximate weights are as follows:

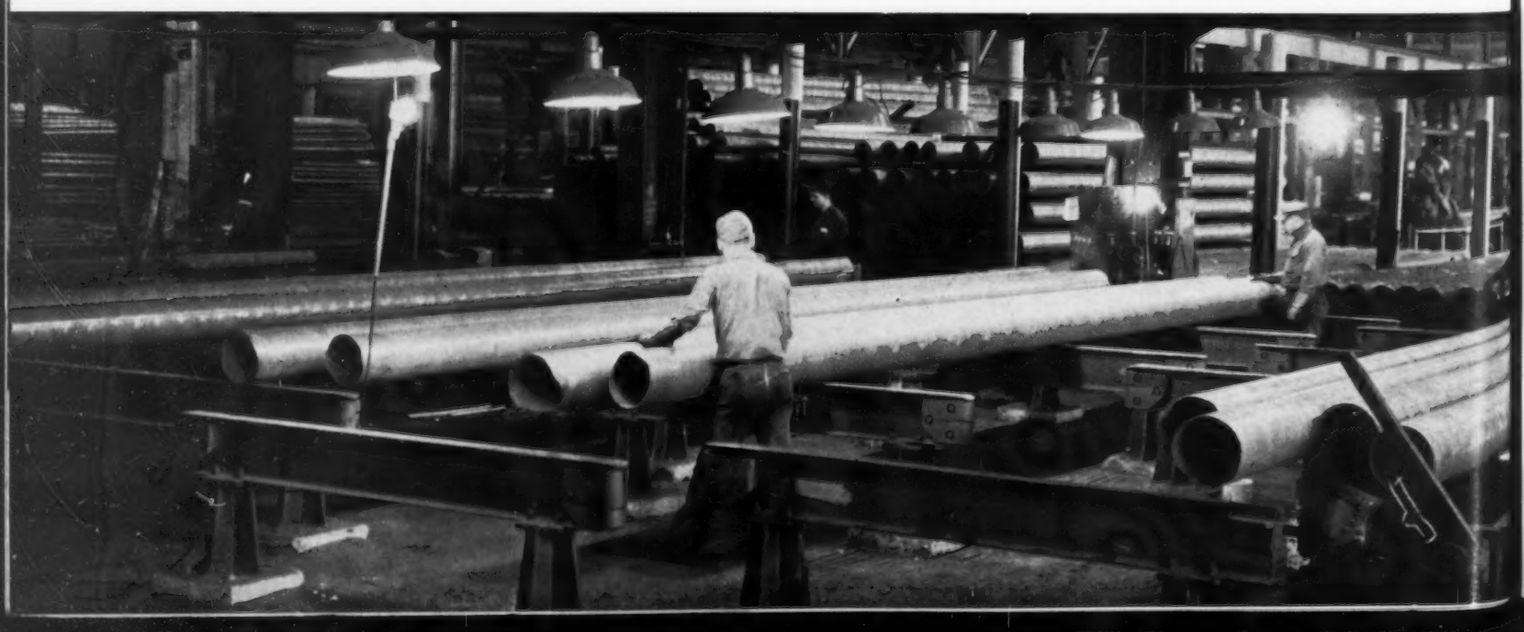
Each piercing mill	510,000 lb.
Each drive	490,000 lb.
1st inlet table	90,000 lb.
1st outlet table	175,000 lb.
2nd inlet table	105,000 lb.
2nd outlet table	210,000 lb.

The plug mill has rolls 38 in. diameter x 56 in. long. It is direct-driven by a 2000 hp. 68 rpm. synchronous motor.

Return rolls are 28 in. diameter x 54 in. long running at 138/404 rpm. and are driven through a gear reducer by a 150 hp. 400 to 1200 rpm. motor. The two reelers are of the barrel type with 30 in. diameter x 28 in. long rolls having a fixed obliquity of 6 degrees. The speed is 104 to 185 rpm. and the motor 650 hp. 225 to 400 rpm.

The sizing mill is designed with 5 pairs of rolls 32 in. diameter x 21 in. long running at a speed of 36 rpm. Driving motor is 700 hp. 393 rpm., induction type.

From the foregoing, we see that great progress has been made during the last forty years in the manufacture of seamless tubes by the Mannesmann method, but there still remain improvements to be made in order to meet the more severe specifications, particularly with respect to dimensional tolerances, which are likely to appear. This will be a difficult problem. How it will be solved, whether by modifications to or combinations of methods used today, or by an entirely new process, is hard to foretell, but when necessity arises it will be done because American steel operators and engineers do not accept defeat.



Allison J. Thompson

1865 -- 1939

Allison J. Thompson, founder and former president of the Thompson Electric Company, and for many years a prominent figure in Association activities, died July 25th in Cleveland.

Mr. Thompson, inventor and author of a number of treatises on economics, was born in Bainbridge, Ohio, and later moved to Cleveland. After attending Central High School there, he read law in the offices of Blandon and Rice, later serving as officer manager of the company until he was appointed manager of the Excelo Art Lamp Company of New York, a position he held two years.

In 1910 Mr. Thompson invented a hanger to lower industrial lamps for cleaning or repairs, and founded the Thompson Electric Company for the production and distribution of this and allied devices for illumination maintenance. He retired from active control of the company last September.

Always an active participant in Association functions, Mr. Thompson's death brings grief to the Association membership as well as to his many friends throughout the industry.

John Howard Albrecht

1888 -- 1939

John Howard (Jerry) Albrecht, well known in the iron and steel industry, manufacturers' agent for several companies producing various items of electrical fittings and supplies, died in Pittsburgh, July 27th.

Mr. Albrecht was born and raised in Pittsburgh, subsequently graduating in 1910 from University of Michigan in electrical engineering. He worked in the testing and steel mill divisions of Westinghouse Electric and Manufacturing Company until 1917. After a period of service in the U. S. Army signal corps, he established the sales agency which he maintained until his death. He was a member of the Association since 1914, and during these 25 years gave his services untiringly to the Association.

To his host of friends in the steel industry, "Jerry's" untimely passing is a grief-fraught shock. His business activities, coupled with his active interest and services at all Association affairs, ripened casual acquaintance into lasting friendships, and a keen sense of loss must follow his death.

Types of Lubrication Essential to Steel Mill Operation

▲ THE lubrication of steel mill equipment is probably more difficult than that of any other industry because of the various types of equipment and the adverse conditions under which much of it must operate. In the large steel mill there is almost every imaginable type of machine ranging from large slow-speed machines to small compact high-speed units operating at various degrees of mechanical efficiency depending to some extent on effective lubrication.

When lubrication recommendations are offered for steel mill equipment, due consideration should be given the fact that effective lubrication implies not only the selection of the proper lubricant but also its proper application. These recommendations are influenced by such factors as:

1. Location of the mill:
   - A. Variations in climatic conditions.
   - B. Proximity to source of cooling water.
   - C. Proximity to industries having contaminating effect on the atmosphere.
2. Type and age of mill:
   - A. Modern or antiquated equipment.
   - B. Plans for future replacement of machinery.
3. Operating conditions:
   - A. Possibility of lubricant contamination.
   - B. Use of salt as scale remover.
   - C. Methods employed in cleaning equipment.
   - D. Heat conditions.
   - E. Time allowed for lubrication and repairs.

LOCATION OF MILL

When considering lubricants for a mill, we should take into consideration its geographical location; its proximity to other industries which might contaminate the surrounding atmosphere; and its location with respect to a source of cooling water.

Mills located in predominantly cold climates are often compelled to use extremely low pour-test lubricants which are more expensive than higher pour-test lubricants which may be satisfactory in more temperate climates for such equipment as worm and spur gear speed reducers, roll table enclosed gear drives, etc. Centralized grease systems operating in cold climates are usually installed with steam lines tracing the grease lines thus enabling the line resistance of the grease to be controlled with auxiliary heat, thus permitting the use of one grade of grease the year around. Winter and summer grades of grease are often desirable for these systems in the South where it is not common practice to install steam tracers.

Lubricants used on machinery operating near lime kilns, cement plants, chemical plants, crushers or even blast furnaces may be contaminated with the dust or fumes from these industries making it advisable to take advantage of the better sealing properties of grease instead of oil on many of the moving parts. Oils in circulating systems installed adjacent to pickling or acid producing processes have become contaminated with acid or other impurities from the atmosphere and caused rapid oxidation of the oil necessitating frequent renewal of the oil. In such cases the use of a good quality inexpensive oil would be more economical than a more expensive product of turbine oil quality.

From a lubrication standpoint, mills located near a plentiful supply of cool, clean water have a distinct advantage over mills which must rely on reclaimed water. It is difficult to maintain water-cooled bearings at normal temperatures therefore higher viscosity oils must be used. The life of non-metallic bearings is less where water conditions are unfavorable and these bearings may even prove impractical in favor of oil or grease lubricated bearings. Where ample cool water is not available, greases with higher melting points and lower penetration numbers are sometimes required to obtain proper lubrication.

TYPE AND AGE OF THE MILL

Experience has taught us to anticipate lubrication difficulties which are often encountered in certain types of mills, therefore it is advisable to consider the type of mill and the age of its equipment when lubricants are recommended. An oil of turbine oil quality or even a good grade of engine oil would not be recommended for badly worn line shaft bearings in an antiquated old mill when black oil or steam refined stocks would probably provide satisfactory lubrication at less cost and result in lower consumption.

Consideration should be given to the possibility of future replacement of obsolete equipment in which case lower quality lubricants could be used if there is no danger of immediate failure of the machine which might result in a mill delay, and if there is no possibility of showing a power saving with a better product. On the other hand, in a modern mill or an old mill which is in good mechanical condition high quality products should be given every consideration where their use is warranted.

OPERATING CONDITIONS

In addition to numerous types and sizes of machines in the steel mill operating at various speeds and loads, there exists a major problem of lubricant contamination with mill scale, dust and cooling water which tends to destroy the efforts of the machinery manufacturer and

LUBRICANTS FOR STEEL MILLS

By W. H. MANDY, Texas Company
BIRMINGHAM, ALABAMA

Presented before A. I. & S. E. Spring Conference, Birmingham, Alabama, March 27 and 28, 1939.

lubrication engineer. The degree of contamination often influences the choice of the lubricant. For example, in an improperly sealed enclosed gear-housing it is not economical to use a high-quality expensive oil or gear lubricant because it is soon contaminated to such extent that it affords no better protection than would a cheaper product. The proper remedy would be to seal the housing but until this is done it would be satisfactory to use a cheaper lubricant which should be renewed frequently. If proper sealing is not possible nor practical it would be advisable to discontinue bath-lubrication and lubricate the gears as though they were open or exposed gears. Where bath-lubrication is preferred, the lowest viscosity lubricant which will prevent wear of the gears should be used because the low viscosity product will more readily allow the foreign matter to settle out and remain on the bottom of the housing. The installation of an oil circulating system with a settling tank and filter would be helpful under these conditions. Where serious contamination is occurring, high viscosity lubricants such as the semi-fluid naphthenic residuums and the fibrous type gear lubricants should never be used in the housing of bath lubricated gears because a pasty, gritty emulsion readily forms and acts as a grinding compound. This has happened with lubricants as light as steam refined stocks and steam cylinder oils. A fairly low-viscosity non-emulsifying lubricant having extreme pressure properties has been used quite successfully where only water enters the gear housing. In this case an overflow connection was made to prevent the lubricant from being floated out.

When rolling plates and slabs on the conventional two and three-high mills, salt is sometimes thrown on the slab to aid in the removal of scale but this practice is detrimental to good lubrication because of the corrosive effect of the salt water. Hydraulic sprays, used in conjunction with the salt, force the salty water into the bearings and gear-housings of the roller tables. It is almost impossible to adequately seal the bearings to permit the use of oil in them under these conditions, therefore a lime soap grease, as heavy as can be applied through the pressure guns, seems to be the best solution to this problem if applied at frequent intervals and in sufficient quantity to provide a seal and keep the bearings flushed out.

When cleaning up machinery and washing mill scale from the roller tables and drives with high pressure water, air or steam, care should be exercised not to direct the force of the stream against the bearing seals and gear covers because considerable dirt, scale and water might be forced in and cause serious damage even though no appreciable contamination occurs during the actual operation of the mill.

HEAT CONDITIONS

Difficulties due to extremely high temperatures are not easily remedied because these heat conditions are not uniform. Since heat is radiated from the product being rolled, transferred and sheared, it is readily understood that when the equipment starts operating, after being idle for several hours, its temperature is normal or even chilled in cold weather and considerable time is required for it to reach its maximum temperature. If a lubricant designed to meet an extremely high temperature is installed, improper lubrication may result until the equipment reaches a temperature sufficient to make the lubricant effective. Some high-temperature greases are capable of providing lubrication at normal temperatures and still are resistant to extreme temperatures. Others designed for high temperatures however may afford little or no protection under normal or cold conditions.

When practical, oil circulation to those parts of the equipment subjected to extreme temperatures provides the best lubrication because the excess heat can be absorbed by the oil, which is externally cooled and recirculated. For this service the oil should have just sufficient viscosity at its maximum operating temperature to prevent wear and to provide an adequate seal, be-

cause the lower the viscosity the more heat will be carried away and the easier it can be cooled and kept in good condition. The oil should also have good demulsibility especially if there is a possibility of water entering the system. If oil circulation is impractical the equipment should be water jacketed in which case oil or grease may be used as a lubricant. When neither oil circulation nor water cooling is practical, a soda soap base grease containing a high-viscosity, high-flash point steam cylinder oil should be used. Under extremely high temperatures even this grease will be decomposed in time and the oil will be distilled off leaving a residue which must be flushed out occasionally with a light oil. Sometimes this residue can be prevented from accumulating by frequent application of an excessive amount of grease but this procedure results in high lubricant cost.

Ample time must be provided on the operating schedule for the maintenance department to attend to necessary repairs to machinery and lubricating systems and to lubricate such equipment which cannot be lubricated while the mill is operating. Neglect of either directly affects the cost of the other because effective lubrication is a major factor in low maintenance cost and unless the equipment is properly maintained low lubrication costs are impossible.

Centralized and automatic oil and grease systems help reduce the time required for lubrication and allow the maintenance crews to devote more time to repairs while the mill is idle. Much of the maintenance on these systems can be done while the mill is in operation. The ultimate success of these systems depends upon the extent to which the maintenance crews acquaint themselves with all details of the construction and proper operation of the systems.

GENERAL KNOWLEDGE OF LUBRICANTS IN USE

Nearly all steel companies today have in their employ a lubrication engineer to assist the operating, purchasing and engineering departments in improving lubrication at a minimum cost by suggesting proper application and purchase of lubricants and by checking the design of new equipment before it is installed to be sure that the best lubricating methods have been incorporated.

A great many lubricants confront the maintenance superintendents and foremen of most steel mills in spite of their efforts to hold their requirements to a minimum and they usually have adequate knowledge of the various lubricants which come under their supervision, but a good knowledge of the characteristics of all available lubricants is helpful in many ways and may save them considerable grief. They have an excellent opportunity to learn the qualities as well as the limitations of these lubricants and it behooves the lubrication engineer to discuss lubrication with these men because such discussions are usually to their mutual advantage. There is so much yet to be learned about lubricants and lubricating methods that it is absolute folly for anyone to assume that his ideas on the subject are final.

THE NAMING OF LUBRICANTS

Many oils such as steam cylinder, engine, turbine, air compressor, journal, bearing and gear oils originally received their names from the equipment which they lubricated. This was likewise true of such greases as pinion grease, anti-friction bearing grease, gear shields, hot and cold neck grease, but a few greases, such as cup grease and pressure gun grease, received their names from their method of application. They have retained their names through the years and even today the mention of any of these products brings to mind a fair idea of their general characteristics. Many lubricants are purchased and used today under their original names even though the service for which they are purchased is entirely foreign to that for which they were formerly used; for example, steam cylinder oil is in general use in small worm gear speed reducers, air compressor oil is in many electric motor bearings and turbine oils are used for air compressors and in circulating systems. This is confusing to those who are just getting acquainted with lubrication so, for this reason, the lubricant manufacturer prefers to omit any reference to the use of the lubricant when brand names are applied to their products. Where brand names are used, the lubrication engineer can recommend one lubricant for various purposes without instilling doubt in the minds of those in the plant who might have the idea that each piece of equipment must have a special lubricant.

DESCRIPTION AND USES OF LUBRICANTS

In addition to a few specialty lubricants, the following types of oils and greases are usually found in most steel mills:

1. Black oils.
2. Journal oils.
3. Red engine oils.
4. Pale oils.
5. Turbine oils.
6. Steam cylinder oils.
7. Cup greases.
8. Low melting point pressure gun grease.
9. High melting point pressure gun grease.
10. Extreme pressure grease.
11. Extreme pressure gear lubricants.
12. Heavy gear compounds.
13. Hard tallow or cold neck greases.
14. Hot neck grease.

When you consider that several viscosities of most of the above oils and two or more consistencies of some of the greases are required you can see that the number of lubricants used is quite large. We still have our old mills with their comparatively crude methods of lubrication so it is necessary that several of the above lubricants be continued in use even though the modern mills have no requirement for such products. In some cases the higher quality products, required in the modern mill, have been used to advantage in the old mills but, generally speaking, the use of these more expensive lubricants is not warranted in the older equipment.

Black oil is the cheapest and least refined lubricating oil in the steel mill. It is usually applied by hand with the long-spout oil can and its use is confined to old slow-

moving machinery which cannot be lubricated without considerable waste. Although available in viscosities from 300 seconds at 100 degrees F. to 130 at 210 degrees F. only about two grades are used in any mill. The modern mill has no place for this product but it is still used in the old mills on sleeve bearings, chains, conveyor links, guides, skids, wire ropes and pig machines.

Journal oils often referred to as bearing oils and mill oils are a better class of oil than black oil and in some mills have replaced the latter entirely. They are blends of steam refined stocks with lighter oils depending upon the desired viscosity; they are dark green in color with fairly high flash point but their carbon residue and pour tests are quite high and they do not separate readily from water. These oils are used to a limited extent in the modern mill and have extensive use in the older mills for the same service mentioned above for black oil, but in addition are recommended for more important equipment such as screw-down drives; screws and nuts; table drives and bearings; shear bearings, eccentrics, clutches and guides; manipulator drives, guides and bearings; straighteners; reheating furnace pushers; tilting mechanism on mill tables; cooling bed sheaves and enclosed drives; oil lubricated pinion and spindle carrier bearings; scrap conveyors; billet and slab transfer drives and conveyors; ingot and hot slab buggies; line shaft bearings; and waste-packed bearings on cranes and open hearth ladle and charging pan cars.

Red engine oil always has a place in the steel mill and is usually found there in two or more viscosities. It is available in many viscosities ranging from 150 to 1500 seconds at 100 degrees F. but the more popular ones are the 150, 300 and 500 viscosity products because the journal oils come into more general use when viscosities higher than 500 seconds are required. These oils are reddish brown in color, are slightly transparent, have fairly low pour and carbon residue tests, medium flash points and only fair ability to separate from water.

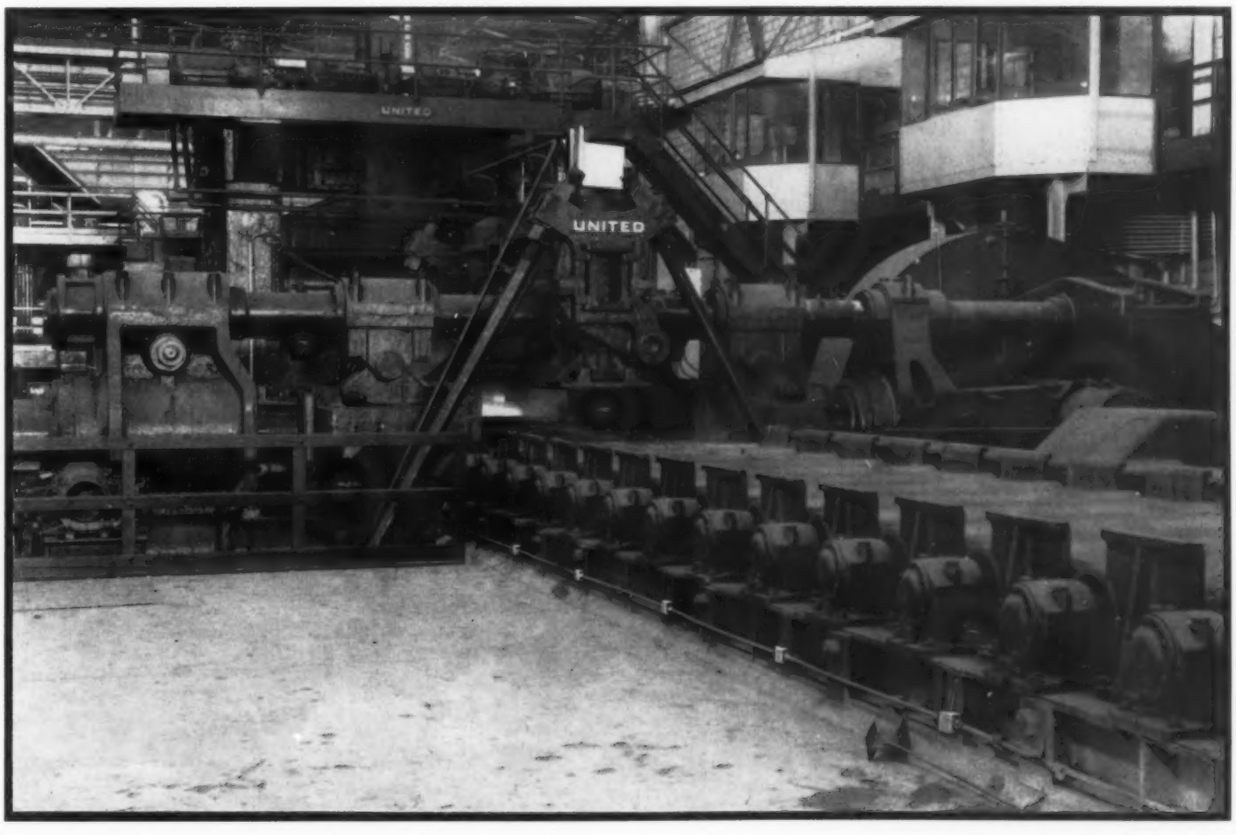
They find general use in the mills and shops for plain bearing lubrication where heat and load conditions are normal and where speeds are medium or high. They are often used in preference to the black oils and journal oils where better quality and lower viscosity oils are desirable and where the bearings have smaller clearances and are better sealed.

Engine oils up to 300 second viscosity are successfully used in ring-oiled bearings of electric motors, fans and centrifugal pumps; in line shaft bearings and on the various machines in the machine and roll shops; shear drive bearings; and circulated by a small pump to the high speed bearings on hot and cold saws in the rail and structural mills. The 300 and 500 viscosity red oils are used on the bearings of large reduction gear drives where the gears are both lubricated with gear compounds and the bearings are supplied from an oil circulating system.

Red engine oils applied by wick-feed or drip cups are sometimes used on roll necks of roller-levelers in sheet and tin plate mills but due to their tendency to crawl out on the rollers, grease is preferred for these machines.

Pale oils have a limited use in steel mills, unless pur-

Grease lubrication on modern equipment is provided by efficient, well-planned systems, insuring effective and economical service.



chased in tank-car quantities for general use as a high grade engine oil, because their viscosity range almost parallels that of the red engine oil group and the quality of these oils lies between the red engine oil and turbine grade oil groups. They are more highly refined than the red engine oils but do not have the quality of turbine grade oils. They are pale yellow in color, have low pour and carbon-residue tests and better demulsibility than red oils, therefore they are preferable for electric motor bearings, air compressors and circulating systems.

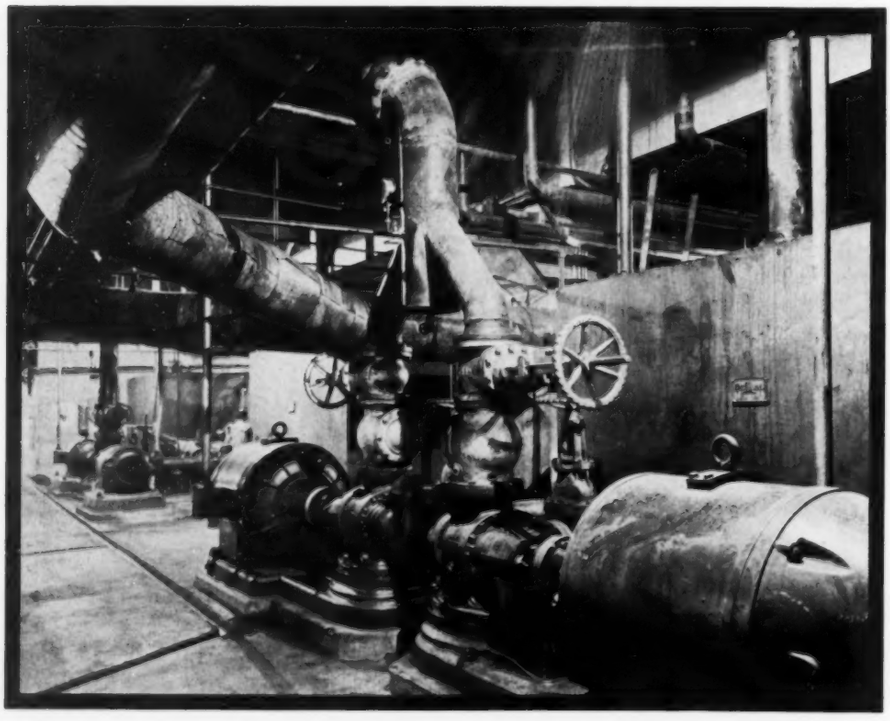
Turbine grade oils are the most highly refined of all lubricating oils used in steel mills, therefore higher in price. The pour test, carbon residue, neutralization and demulsibility numbers are better than those of any of the other oils, thus they are ideal for circulating systems because they separate quickly from water and other foreign materials and resist oxidation for long periods under adverse operating conditions. As their name implies, these oils were originally manufactured for steam turbine service. The lower viscosities, from 150 to 200 seconds at 100 degrees F. are for turbine bearings while the higher viscosities up to approximately 500 seconds are for geared turbines where the same lubricant is supplied to the bearings under pressure and also sprayed on the reduction gears.

These oils are available in viscosities up to 2400 seconds at 100 degrees F. The higher viscosity oils were designed to meet the specifications of the manufacturers of the oil-film bearings which came into prominent use on the four-high strip mills.

Turbine oils having viscosities of 150 to 300 seconds at 100 degrees F. are being used to a great extent in the modern steel mills in circulating systems providing lubrication to the ring oiled bearings of main electric motor drives. The circulating system provides that additional insurance against bearing failures in case the oil rings fail to function or the bearing develops abnormal heat in which case the continuous supply of clean, cool oil carries off the heat and keeps dust and other foreign matter flushed out of the bearing into the settling tank or filter of the system.

The high quality and especially the low carbon residue of turbine oils has been recognized to the extent that they are being used more and more for cylinder lubrication of air compressors. Viscosities of from 300 to 500 seconds at 100 degrees F. are usually preferred for this service.

Steam cylinder oils are dark green, high viscosity and high flash point oils available in numerous grades or qualities depending upon the degree of refinement and treatment. They are available in viscosities ranging from about 100 to 290 seconds at 210 degrees F. and are of two types, that is straight mineral and compounded with 5 to 15 per cent animal or vegetable oil. The reason for compounding these oils is to enable them to be used more efficiently and economically when applied to the valves and cylinders of steam engines where they come in contact with moist steam. The greater the amount of water in the steam the more compound is required; accordingly with dry or superheated steam, less compound is needed and even straight mineral oil may be desirable. The moisture in the steam emulsifies the fixed oils and allows the film of lubricant to cling to the metal surfaces and resist being washed out. Ordinary grades of cylinder oil are not dewaxed, nor very highly filtered, therefore their pour points and carbon residues are higher than those of the more highly filtered stocks. Another factor entering into the quality of a steam cylinder oil is the type and percentage of animal or vegetable oils known as fixed oils. These fixed oils are rather expensive and vary in price, therefore, the price of the steam cylinder oil



Modern oil lubrication is usually effected by large circulating systems located in convenient oil cellars.

varies according to the type of cylinder stock and the type and percentage of fixed oil present.

This oil is used to lubricate the cylinders and valves of steam engines of main mill drives and table drives; vertical and horizontal blowing-engines; steam driven air compressors, hydraulic and boiler-feed pumps; steam locomotives and cranes in the mill. The type and method of application of cylinder oils must be given careful consideration if low oil consumption and proper lubrication is effected in this equipment because most of the steam equipment in steel mills today have seen many years of service and cannot be expected to be in first class mechanical condition.

Other uses for steam cylinder oils are for lubrication of small worm-gear speed reducers and heavy-duty plain bearings such as track wheel bearings on open hearth ladle cranes. The small amount of fixed oil present in this product provides slight extreme pressure properties desirable for this service.

According to the American Society for Testing Materials, "A grease is a combination of a petroleum product and a soap, or a mixture of soaps, suitable for certain types of lubrication." Graphite, mica, asbestos and other fillers are sometimes added for specific purposes. The percentage of soap present in the grease usually governs its consistency, thus the less soap the softer the grease.

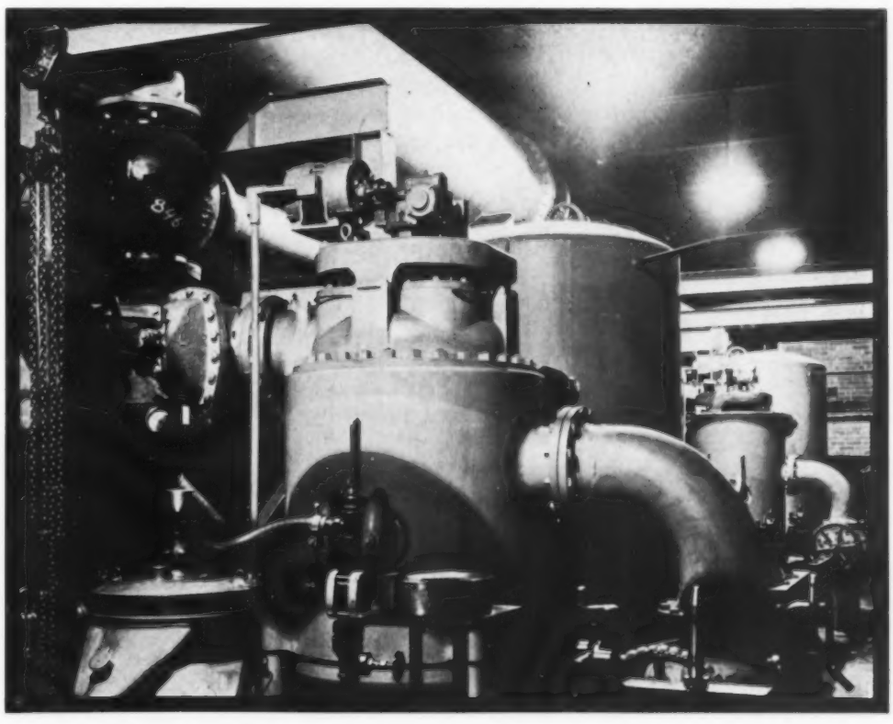
Grease has lubricating properties similar and superior, under certain conditions, to a straight mineral oil. The chief advantages of grease over oil is its longer lasting qualities or its tendency to stay put for longer periods of time; and its tendency to resist being squeezed out from between bearing surfaces which are subjected to high unit pressures or repeated shock loads. These qualities are continually making grease more popular every day for such conditions where:

1. It is desirable for the lubricant to serve the combined purposes of lubricating a bearing and sealing it against entrance of water, dust, scale and other foreign matter.
2. The point requiring lubricant is concealed and so protected that it is apt to be overlooked, or where it is not easily accessible.
3. The equipment is so badly worn that it is impossible to retain oil, or where the mechanical design will not permit oil-tight housings and seals.
4. The bearing surfaces are subjected to repeated shock loads which might cause rupture of an oil film.
5. Unit pressures are so high that an oil film cannot be maintained.
6. The bearing or journal is subjected to high temperatures, and where it is impractical to circulate sufficient oil through the bearing to dissipate the excess heat.

Probably the greatest disadvantage of a grease, compared to an oil, is its greater internal resistance which exerts a greater load on the moving parts resulting in greater power loss. Grease, therefore, has a definite place as a lubricant but it should not be substituted for oil without considering the advantages and disadvantages of each.

Cup greases contain low viscosity oils and have a lime-soap base which gives it a smooth buttery texture and makes it insoluble in water. They are not designed for high temperatures and if used at high temperatures the chemical combination between the oil and soap is destroyed and separation will result, therefore their use should be limited to a maximum temperature of about 175 degrees F.

Cup greases are available in several consistencies or penetration numbers ranging from 340 to 70. It is used



The responsibility of lubricating thousands of points in present day mill machinery places exacting demands on lubrication equipment.

in much the same service, where grease is preferred, that black oil is used; that is, on slow speed plain bearings, guides and slides where temperatures are normal and where the mechanical condition of the equipment is such that high consumption of the lubricant cannot be avoided. They should not be used in centralized systems because of the possibility of separation when subjected to high pressures for long periods, however, the softer grades are often applied through pressure fittings with a grease gun.

Low melting point pressure gun greases are similar in many respects to cup greases but are better quality products containing better grades of fats and higher viscosity oils of better quality. They usually have a lime or an aluminum soap base which makes them insoluble in water but not resistant to high temperatures, therefore, they should not be subjected to temperatures higher than that recommended for the cup greases. They are more stable in regard to resistance to separation and can be used in centralized grease systems but care should be taken not to over-heat the lubricant in the supply lines which in some localities are paralleled by a steam line. These greases are widely used in the steel mill and often supplant the use of cup grease altogether. Where temperatures and pressures are normal, the low melting point pressure gun greases are used in almost all plain and roller bearings on mill tables, manipulators, hydraulic pumps, roll balance mechanism, guides, presses, punches, shears, overhead cranes, conveyors and bucket elevators.

High melting point-pressure gun greases have either a 100 per cent soda soap base or a mixture of lime and soda soaps and contain either a good quality, high viscosity pale oil or a dewaxed, filtered cylinder stock oil which gives them the ability to withstand high temperatures up to about 400 degrees F. depending upon the consistency. These greases provide a tough, durable, long lasting lubricating film which has the ability to withstand heavy pressures and shock loads.

To a certain extent these greases are soluble in water but this does not mean that they cannot be used in the presence of water because their excellent sealing properties prevent the actual entrance of water into the bearing. Any soluble action that water might have would affect only the grease which has been forced out of the bearing. Their soluble nature, however, is a factor which cannot be dismissed entirely when considering lubrication under extreme water conditions.

These greases are used in many mills for much of the same service that the lower melting point grease is used and in addition they are recommended where heat conditions prevent the use of lime soap lubricants. The softer grades are often preferred for the anti-friction bearings of electric motors because of their ability to stay in the bearing and not get into the motor windings. The heavier grades are recommended by the manufacturers of certain types of flexible couplings because of their adhesive nature and heavy oil content. These greases are satisfactory for feeder and catcher tables in sheet mills; the door lifting rigging and conveyor drives around reheating furnaces; open hearth charging cranes; blooming mill and plate mill shears and roller tables.

Although the price of these high melting point greases is higher than that of the lime soap greases, their consumption is comparatively lower and the ultimate cost is usually favorable where they are properly recommended.

Extreme pressure greases resemble the pressure gun greases except that they contain one or more extreme pressure agents such as sulphurized oils, chlorinated oils or lead base soaps or a combination of these. They were designed especially for heavy-duty bearings for application by means of the centralized grease systems. The consistency of this type of grease must therefore be limited to the higher penetration numbers which can be pumped through grease headers to the various parts of the mill from a central station.

Many anti-friction bearing manufacturers are partial to the extreme pressure greases for their bearings used

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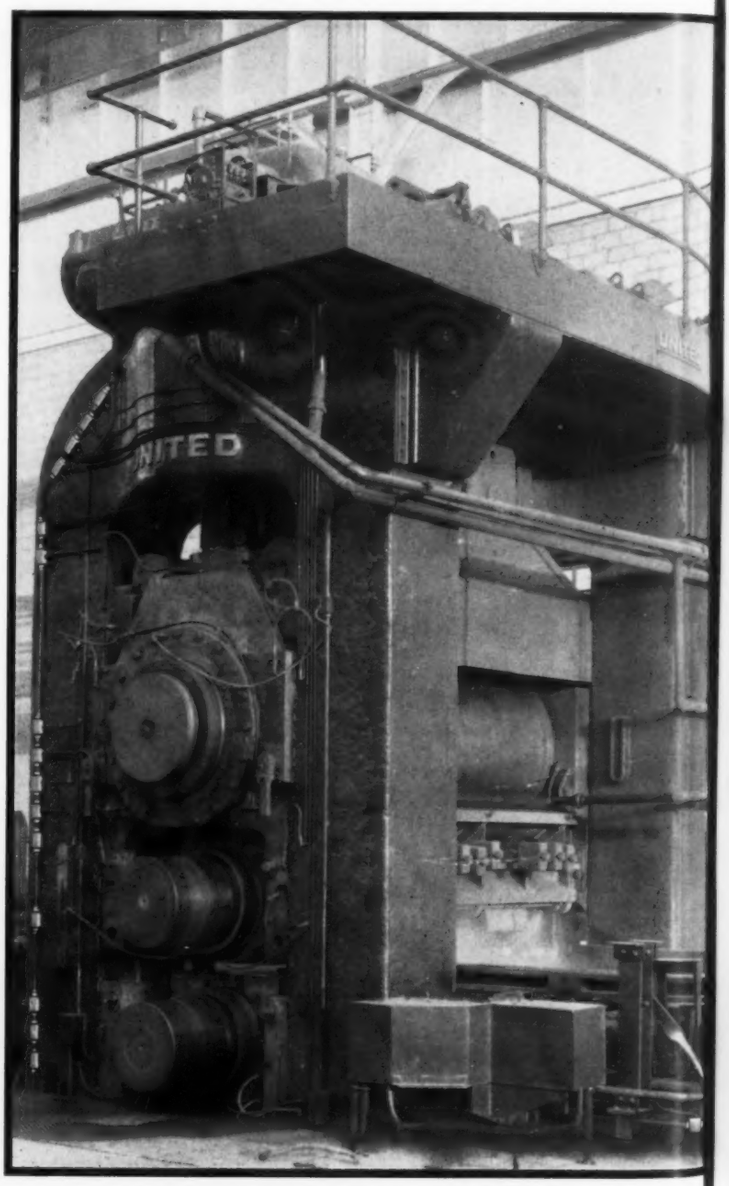
In the modern wide strip mill, lubrication and the equipment for its application have reached a high stage of development.



in heavy duty service because even though excellent results are often obtained with the standard types of greases, there is always the possibility that operating conditions will cause overloading of the bearing. The extreme pressure greases are better adapted to take care of these overload conditions and they are good insurance against high maintenance costs and delays in operation.

The advent of the continuous type mill has brought the extreme pressure greases to the front for use in the heavy-duty roller bearings installed on the work-rolls and back-up rolls of these mills. Due to the success of these greases on the roll stand bearings many mills have realized the advantage of extending the centralized systems to include the mill tables, manipulators, screw-down and roll balance equipment, in which case the same grease is used throughout.

Extreme pressure gear lubricants are another class of lubricants with extreme pressure characteristics used extensively in the modern steel mills. They are fluid or semi-fluid gear and bearing lubricants consisting of medium to high viscosity, low pour point oil stocks permanently combined with sulphurized, chlorinated and lead soap base compounds to produce a product with a film strength from three to five times as great as that of a straight mineral oil of corresponding viscosity.

The increased operating speeds and pressures of more recently designed pinion and reduction gear sets have made the use of these extreme pressure fluid lubricants almost indispensable especially when it is desirable to use the same lubricant for both gears and bearings of the unit. The conventional method of application of these products is either bath lubrication or circulating systems which supply the bearings and spray the lubricant on the gears at their meshing point. In the case of heavy duty pinion stands operating at high speeds, it is often necessary to use a lower viscosity lubricant on the bearings than is required for ample protection of the gears. In such cases a separate circulating system is installed for the bearings.

Where two different viscosity lubricants are used it is practically impossible to prevent their mixing and the usual tendency is for the bearing lubricant to get by the seals into the gear lubricant thus reducing the viscosity of the latter. This is offset to a certain extent, however, by the tendency of extreme pressure lubricants to thicken slightly in service. When the viscosity of the gear lubricant has been reduced too much, a portion of it can be replaced with a considerably higher viscosity product to give a resulting mixture equal to the original viscosity.

Viscosity tests should be made on the gear lubricants every three to six months to ascertain the condition of the gear lubricants. These tests should be made more frequently when a considerable amount of make-up is necessary in the bearing system because there is evidence that contamination is taking place.

Heavy gear compounds are an outgrowth of the old pinion greases which thinned badly and dripped when exposed to a little heat, and were so viscous when cold that they were difficult to apply. Many of them were loaded with fillers of all descriptions and when placed in service they thickened so badly that they had to be renewed frequently.

It was soon found that the product required should not only have adequate body but sufficient cohesiveness to prevent channeling and sufficient adhesiveness to cling. Some of the products on the market today contain pine tar and other resinous materials to make them more adhesive while others are straight mineral products. The better quality products do not thicken in service to a very great extent, but they should be changed occasionally when used in enclosed gear units especially if the heavier grades are used.

These gear coatings are available in a number of consistencies varying in viscosity from 124 to 10,000 seconds at 210 degrees F. universal Saybolt. The lighter grades are used for wire ropes and in enclosed reduction gear units on mill table and line shaft drives. The heavier grades from 1,000 to 5,000 seconds at 210 degrees F. are used for open or exposed gears, exposed pinions and chains and cables subjected to high temperatures. The lubricant is heated and applied by brushing or pouring it on while the gears are turned slowly. These heavier grades are also used as a bath lubrication for some of the large heavy-duty pinion stands and reduction gear sets where oil or grease is used on the pinion necks or journals.

The older steel mills with their more or less obsolete and antiquated equipment were designed to use large quantities of the residuum gear lubricants and many of these old mills are still with us. The more modern mills have a much smaller demand for this product but it is still used for crane cables and other wire ropes; exposed racks and pinions installed on manipulators and furnace pushers and in certain types of flexible couplings. Enclosed bevel gears on drive shafts of mill tables seem to give very satisfactory service with the lower viscosity grades of gear compounds up to 200 or 300 seconds at 210 degrees F. where weather conditions permit the use of such products.

Hard tallow compounds or cold neck greases: Here again we have a grease which has its greatest use in the older mills for the lubrication of the open type roll neck and pinion bearings. It is applied by hand packing directly on the roll necks or journals so they will wipe a film of grease into the bearing. The necks are flooded with water to carry off the heat radiated from the barrel of the roll. The grease should be packed up against the roll neck and against the fillet of the roll frequently if even fair results are obtained.

This grease is a lime-tallow base grease containing a medium viscosity oil and often contains from 5 to 8 per cent powdered graphite. It is quite hard having a penetration number of from 50 to 60. It is a "slippery" type of grease resembling hard butter. This "slippery" characteristic is important because if the grease is tacky or sticky the neck will wipe an excessive film into the bearing at first and after a few minutes operation there is a space between the grease and the neck and the grease will have to be packed up against the neck at very frequent intervals. On the other hand, if the grease is too hard or laminated it breaks up easily and falls out of the bearing.

The hard tallow compound is being rapidly replaced in those new mills, which have the plain babbitt and brass bearings, by a soft pressure gun type grease applied by automatic centralized grease systems.

Hot neck grease: This is used on the roll necks of the old conventional two-high hot mill stands in sheet and

tin plate mills. The grease, as purchased from the manufacturer is really a "mixing grease" which is added in quantities of about 15 per cent into large grease kettles which have been filled with old used grease recovered from under the roll stands. This mixture of old grease and new or mixing grease is melted and run out into cooling pans. When cold it is cut up into blocks of the required size and is then ready for use on the mill.

Some grease manufacturers supply two products to be added to the reclaimed grease. One of these is the base product which is a hard petroleum pitch while the other is a soft "mixing grease" which is required to replenish the lubricant or oil and fat which has been lost from the grease during use on the roll necks and during the cooking process. Other grease manufacturers combine these two products into one "mixing grease". The advantage of the latter is that only one variable is left up to the man in the grease house. If the melting point of the reclaimed grease is too high, he merely increases the amount of new grease and he reduces this amount if the melting point is too low.

The temperature of the roll necks on which hot neck grease is used varies in the different mills from about 300 to 500 degrees F. therefore, it is up to each mill to make their grease to suit their conditions. Some mills are using a grease with a melting point as low as 300 degrees F. while others prefer a melting point of from 380 to 390 degrees F. The melting point must be low enough for the heat of the neck to soften it sufficiently to allow the neck to wipe off a heavy film as it rubs against the stick or block of grease which is laid directly on the neck. If the melting point is too high, naturally the necks do not become coated and poor lubrication results. If the melting point is very much too low there is a chance of the grease splashing out on the sheet which is being rolled. This is especially true if too many sticks of grease are kept piled in on the roll neck.

In the old tin plate mills and in some sheet mills the grease is not applied to the necks in stick form but is melted by a gas flame and swabbed on the necks in liquid form.

For several years now we have seen a closer cooperation between the manufacturer of equipment, the manufacturer of lubricants and the operating and engineering departments of the steel companies. This has been an important factor in the progress made in more economical and efficient lubrication of steel mills which has been brought about by the realization that the lubrication problems of the steel mill must be given every possible consideration. The time has passed when the equipment manufacturer can turn over a piece of modern steel mill equipment to the customer and expect him to operate it efficiently unless the problems of lubrication have been fully considered in the design. The customer's operating departments have brought lubrication difficulties to the attention of the equipment manufacturer who has in turn called upon the lubricant manufacturer for help. Through their combined efforts and experience our modern steel mill machinery is able to produce more product at less lubrication cost, with more cleanliness and safety. Much is still to be done along these lines, however, and we must all continue to work and cooperate with each other.

This desire for better lubrication has led to the greater use of better quality oils and greases which, although, higher in cost per gallon or pound over the ordinary types of lubricants, are usually found to be more economical in the end. We also must give due credit to manufacturers of the elaborate and efficient centralized lubrication systems without which much of the progress in lubricating methods would have been impossible. These systems designed to handle both oils and greases have certainly kept pace with the advancement in lubrication methods and have made it economical and desirable to use the higher quality lubricants because they are a great help in proper application of lubricants with the least effort and waste.

DISCUSSION

PRESENTED BY

T. R. MOXLEY, General Master Mechanic, Wheeling Steel Corporation, Steubenville, Ohio.
W. H. MANDY, Texas Company, Birmingham, Alabama.
F. L. GRAY, Lubrication Engineer, Carnegie-Illinois Steel Corporation, Gary, Indiana.
W. E. HAMILTON, Lubricating Engineer, Tennessee Coal, Iron and Railroad Company, Ensley, Alabama.

T. R. MOXLEY: About what do you consider a safe operating temperature for extreme pressure gear lubricants on large gear reduction drives of, say, 3000 hp.?

W. H. MANDY: That is a difficult question to answer because I do not know how extreme pressure lubricants would be affected if operated at very high temperatures. We caution against using our lead-base extreme pressure lubricants at temperatures above 250 degrees F. and I would prefer to hold them much below this temperature for continuous operation. I would recommend the installation of coolers for the extreme pressure lubricants if the operating temperatures continued to run 180 degrees or more.

T. R. MOXLEY: We are very much concerned in the operation of strip mills. A great many systems for demulsifying oil, after it has been in the system for even a short length of time, have not proven satisfactory. Could you give us information on that?

W. H. MANDY: It is true that the demulsibility number of the high viscosity oils, used in circulating systems of wide strip mills, drops appreciably within a few weeks after they are put in operation because it is impossible to install and maintain a circulating system absolutely free of all foreign matter. In spite of the

efficient seals that have been provided, water and mill dust will contaminate the oil. I believe the reason that most of the systems have failed to clean up the oil properly is that they have not been operated properly. Heat is essential to the proper operation of these systems whether they be just settling tanks or a combina- of settling tanks and centrifugal purifiers. The degree of refinement of the oil in the system also has a bearing on the s..ccessful operation of the circulating systems.

T. R. MOXLEY: After we have encountered contamination from water, in using the centrifuge for demulsifying the oil there is usually more or less loss due to incomplete separation. We take it for granted, of course, that the loss due to sludge, which occurs when an oil demulsifies, can be overcome possibly some day by better grades of oils. Is that possible or not?

W. H. MANDY: Here again the proper operation of the purification systems and the use of a very highly refined oil has a bearing on the amount of sludge present and the amount of loss sustained.

Where the circulating system has two settling tanks, the usual practice is to operate one week on one tank and clean up the oil in the other tank; however, if very much water is entering the system and a highly filtered oil is not used, it will be difficult to operate even one week on a tank and it may be necessary to change tanks more frequently. The oil should be cleaned up before it reaches the stage of sludging and if the tank of oil is taken out of service as soon as it appears to contain water, the oil can be restored to its original condition without much effort. On the other hand, if the oil containing very much water is continued in service it will form sludges which might prove very stubborn and it will be difficult to restore it to its original condition.

If sludge has formed, a considerable amount of good oil can be reclaimed from the sludge by heating it to about 218 degrees F. for several hours. The emulsion must be broken and the more stable the emulsion the more heat is required and the more time is required to clean up the oil.

F. L. GRAY: The lubrication engineer in the steel mill realized from the inception of his job that one of the main problems was the method of education of the operating and maintenance personnel. We can all remember, a few years ago, when the equipment manufacturer paid no attention to how the machine was to be lubricated. We can all remember how our maintenance personnel considered black oil sufficient for bearings, and gear shield sufficient for gears. Beyond that, they knew little, of the requirements, or the methods, or the products at hand.

The Association of Iron and Steel Engineers was possibly among the first engineering societies to realize that this program had to be brought out in the open. Since the organization of the Lubrication Division, we have made great strides in the application of the products of the oil refiner and grease manufacturer, and the designer of the equipment is realizing today that the successful operation of his machine must depend on adequate and efficient lubrication.

Mr. Mandy's paper this morning is a big step in that educational program. He has specifically pointed out the factors that control the selection of a lubricant. He has called attention to the assistance the lubrication engineer is able to render to those responsible for maintenance and operation, and finally, he has given a very conclusive working description of the general products used in our mills. It is a paper that well can be laid up in the files for ready reference where these questions are involved.

W. E. HAMILTON: I would like to question Mr. Mandy regarding the possibility of recovery of leaded compounds. Further, if there are any experiments on such recovery in progress, or has anyone been successful in the recovery of these extreme pressure gear compounds?

W. H. MANDY: We have taken samples of these lead compounds after they have been in service around eight to ten months and centrifuged them, and we find there is no separation of lead soaps, with some leaded compounds. The usual thing you run into is where somebody has endeavored to load the oils with more extreme pressure compound than can be dissolved in the oil. In that case you will throw out the excess lead soaps, but you do not affect your better compounded products if they are manufactured properly. That has been actually demonstrated by tests.

W. E. HAMILTON: I would like to question Mr. Mandy in regard to centrifuging. I suppose each plant has its pet means of purifying its circulating oils. In our case we find we can purify our oils almost from a stable emulsion to a good oil without the use of centrifuge, merely by means of heat. I would like an opinion as to whether constant centrifuging has a detrimental effect on circulating oils.

W. H. MANDY: The centrifuging of oil seems to be more or less a pet with some of us but is frowned on by others. When dealing with high viscosity oils, unless you heat the oil to a proper temperature and have the centrifuge set-up properly it is very easy to waste considerable oil and the oil can be discharged from the centrifuge in worse condition than when it entered.

There is no doubt that the centrifuge is a material aid in keeping the oil in a circulating system free from water and other foreign matter if it is operated properly. Mr. Hamilton stated that he has been able to keep his oil in excellent condition merely by the use of settling tanks equipped with steam coils. The use of settling tanks enables the water and most of the heavier particles of solid matter to drop out of the oil and the oil looks clean but there is some doubt in my mind that the very fine dust and mill scale settles out. This finely divided foreign matter may not be detrimental from a lubrication standpoint but it does act as a catalytic agent causing the oil to form sludge more readily. The centrifuge will, under proper operating conditions, remove more of this finely divided foreign matter than by merely heating the oil and allowing it to settle.

Regarding Mr. Hamilton's last question, I do not think constant centrifuging of the oil would be detrimental to it unless the oil is maintained at a very high temperature.

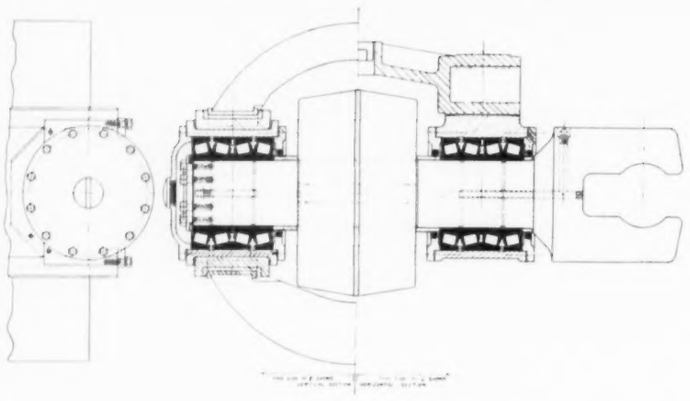


FIGURE 1—Typical main roll bearing application on piercing mill.

Application of BEARINGS

By S. M. WECKSTEIN, *Chief Engineer*
Timken Roller Bearing Co.
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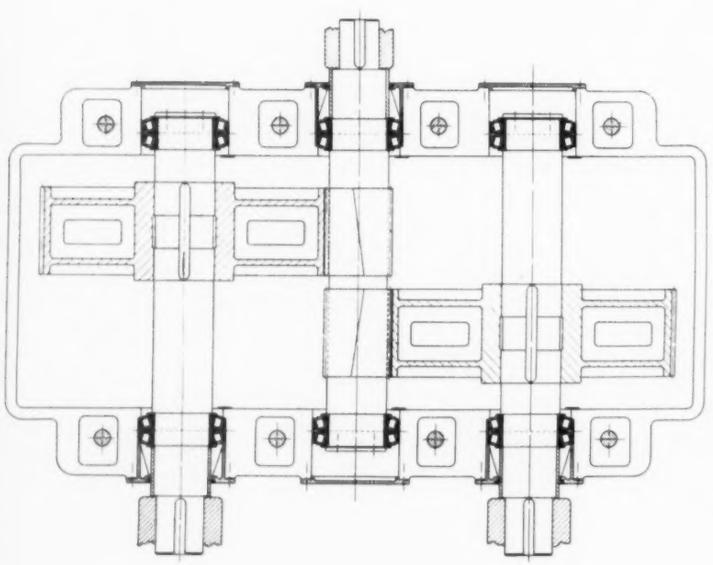
▲ THE increasing demand for tubular products in various types of machinery and in manufacturing processes has led to closer consideration, on the part of the steel industry, to the manufacture of tubes. This paper is intended to give a review of some of the various methods used in the production of both seamless and welded tubes. By means of the various layouts shown, it is intended to point out the use of tapered roller bearings in modern tube mill equipment. No attempt will be made to discuss the advantages or the limitations of the various processes or to compare the production or quality obtained from these processes.

FIGURE 2—Typical arrangement of gear drive for piercing mill.



For the manufacture of seamless tubes, the methods most commonly used in this country are (1) the automatic or plug-mill process, (2) the Diescher process, (3) the Assel process. The Pilger process which is used chiefly in Europe, the push-plug and other special processes will not be covered in this paper.

AUTOMATIC OR PLUG MILL PROCESS

The operation of the modern plug mill can be described briefly as follows: Billets are charged into the piercing mill furnaces and from there into the piercing mill. Two piercing mills may be used, the first for piercing only and the second for enlarging or expanding the pierced billet.

As the billet leaves either of the piercing mills, it is conveyed to the plug or rerolling mill, where the pierced billet is passed back and forth through the rolls in order to reduce the wall thickness and elongate the tube.

After the desired work is completed in the plug mill, the tube is taken to the reeling machine. Here oblique rolls act on the outside of the tube with a cylindrical mandrel on the inside. This operation tends to equalize the wall thickness and smooth the inside and outside surfaces of the tube. During this operation the diameter of the tube is slightly increased because of a reduction of the wall thickness.

From the reeling machine the tube is generally conveyed through a reheating furnace to the sizing mill. In the sizing mill, which consists of a varying number of stands carrying pairs of grooved rolls, the tube is reduced to the required diameter. After leaving the sizing mill, it is taken to the cooling table and from there for further processing.

With this brief discussion of the sequence of operations in the production of the tube, we can now proceed

Anti-Friction in TUBE MILL EQUIPMENT

Presented before A. I. & S. E. Cleveland and Pittsburgh Sections at Youngstown, Ohio, May 2. 1939

with the analysis of the bearing requirements and recommended applications in the major positions of these mills.

The main rolls of the piercing mill are mounted in cradles which can be adjusted to give the desired angularity of the roll for most efficient piercing on a given size billet and at a desired speed. As a result of this requirement the bearings on the main rolls are subjected to thrust loads as well as radial loads. To take care of these loads and still permit of the desired minimum roll diameters, four row tapered roller bearings are used. Figure 1 shows a typical main roll bearing application. The couplings are generally mounted with a heavy press fit on the shaft. The rolls may be mounted against a shoulder on the shaft or against spacers. In the latter arrangement the bores of the two bearings are different in order to facilitate assembly. The bearings are supplied fitted with cup and cone spacers to give the desired running clearance in the bearings. This permits clamping up the bearings between the shoulders or spacers. To facilitate assembly and disassembly of the bearings they are mounted with a loose fit on the necks. The necks are drilled as shown in order to permit of the periodic introduction of grease under the cone bores. This procedure greatly reduces the scuffing of the neck due to the creep of the loose fitted inner races. To further retard this creep and wear, all surfaces contacting the inner races are hardened and slotted to permit lubrication of these contacting faces. In some installations, the inner races are keyed to the necks. Suitable closures of the design shown and with various modifications are used to keep the bearings properly enclosed and lubricated. Proper venting of bearing boxes is recommended.

The bearings are not removed from the roll necks except when the diameter of the roll has been reduced to its minimum dimension. For the periodic dressing of the rolls, the entire roll assembly is mounted in a lathe. The coupling is chucked in the head of the lathe and the roll is driven in that way. To support the opposite end, in the design shown a centered plug is fitted on the end of the shaft and the rolls supported on the tailstock center. In the larger and heavier rolls, the end of the roll is designed so that it extends out through the left hand closure plate and this end is supported in a suitable bearing on the lathe steady rest.

The first application of tapered roller bearings to the main rolls of a piercing mill was made in 1927 at the plant of the Timken Roller Bearing Company. The application was made on a mill using 20 inch diameter rolls. During the first year's operation a very gratifying saving was made over the cost of the brass bearings previously used. A remarkable improvement was noted in the concentricity of the tubes pierced. As a result of this test, the 34 in. piercing mills installed by the Timken Roller Bearing Company in 1929 were equipped with tapered roller bearings. Since that time additional mills at our plant and other plants have been similarly equipped.

To drive the main rolls of these piercing mills, various designs of gear drives have been used. A satisfactory drive design and bearing arrangement is shown in Figure 2. Two row bearings are used in all positions. The inner races are press fitted on the gear shafts while the

FIGURE 3—Roll neck bearing mounting to carry the heavy loads encountered in plug mills.

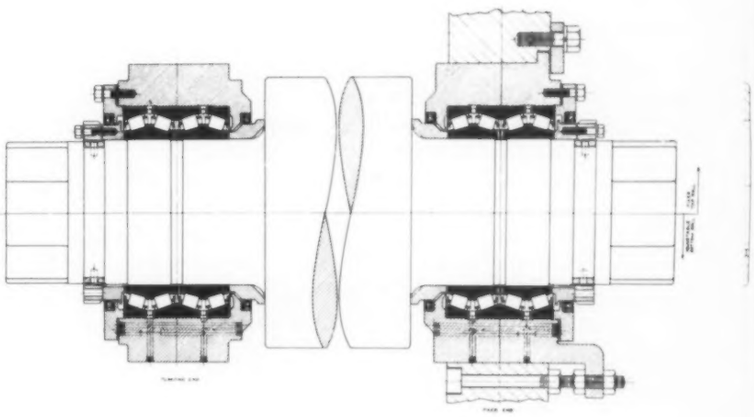
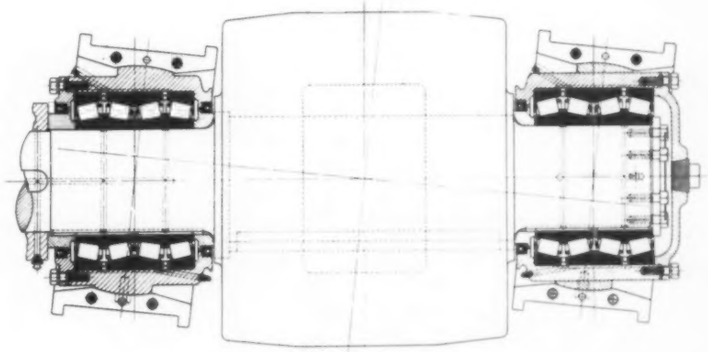
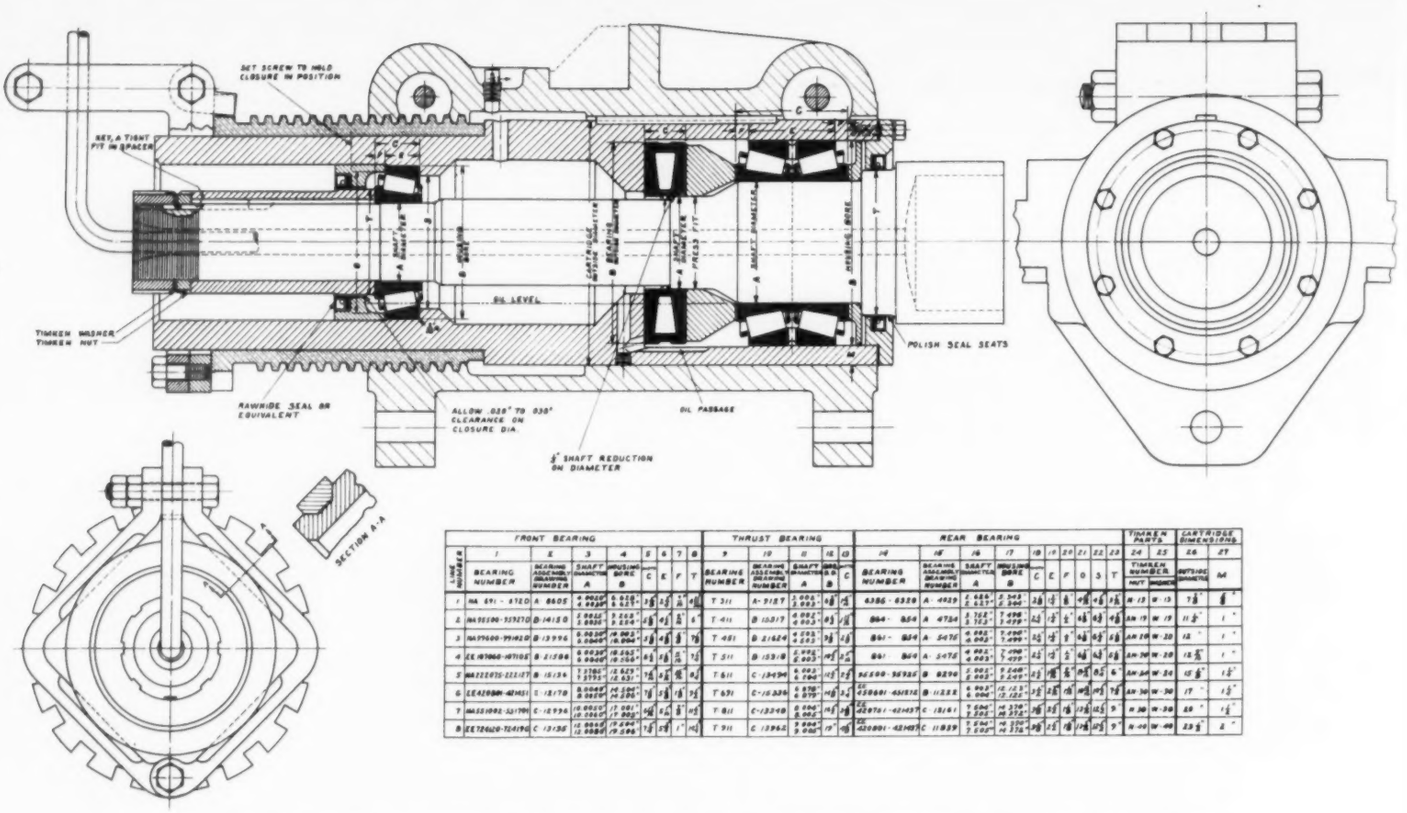


FIGURE 4—Bearing application on reeling machines is similar to that on main piercing rolls.





LINE NUMBER	FRONT BEARING 1 BEARING NUMBER	2 BEARING ASSEMBLY DRAWING NUMBER	3 SHAFT DIAMETER A	4 HOUSING BORE B	5 C	6 E	7 F	8 T	THRUST BEARING 9 BEARING NUMBER	10 BEARING ASSEMBLY DRAWING NUMBER	11 SHAFT DIAMETERS A	12 B	13 C	REAR BEARING 14 BEARING NUMBER	15 BEARING ASSEMBLY DRAWING NUMBER	16 SHAFT DIAMETER A	17 HOUSING BORE B	18 C	19 E	20 F	21 O	22 S	23 T	TIMKEN PARTS 24 TIMKEN NUMBERS NUT	WASHER	CARTRIDGE DIMENSIONS 25 OUTSIDE DIAMETER	26 M	27
1	HA 591 - 6720	A 8805	6.9995" - 7.0000" & 6.9990" - 6.9995"	9.8268" - 9.8298" & 9.8258" - 9.8288"	2 1/8	2 1/2	2 1/2	4 1/8	T 311	A-7157	3.9055" - 3.9080"	4 1/8	1 5/8	6386 - 6320	A - 4929	5.4855" - 5.4875" & 5.4835" - 5.4855"	7.8740" - 7.8790" & 7.8740" - 7.8790"	2 3/8	1 3/8	1	4 1/8	4 3/8	4 3/8	H-13	W-13	7 1/8"	8 1/4"	
2	HA 95590 - 95720	D-14150	7.9965" - 7.9985" & 7.9955" - 7.9975"	9.8268" - 9.8298" & 9.8258" - 9.8288"	2 1/8	2 1/2	2 1/2	4 1/8	T 411	D 13017	4.4975" - 4.5025" & 4.4925" - 4.4975"	3 1/8	1 1/8	864 - 854	A 4724	5.7655" - 5.7725" & 5.7595" - 5.7665"	7.4990" - 7.5090" & 7.4990" - 7.5090"	2 1/2	1 3/8	1	4 1/8	4 3/8	4 3/8	AH-19	W-19	11 1/2"	1"	
3	HA 95600 - 95620	D-13990	6.9985" - 7.0000" & 6.9945" - 6.9960"	10.0965" - 10.1065" & 10.0965" - 10.1065"	2 3/8	2 3/8	2 3/8	4 3/8	T 481	D 21624	4.7525" - 4.7575" & 4.7525" - 4.7575"	3 3/8	1 3/8	861 - 854	A 5476	6.4925" - 6.5025" & 6.4925" - 6.5025"	7.4990" - 7.5090" & 7.4990" - 7.5090"	2 5/8	1 3/8	1	4 3/8	4 3/8	4 3/8	AH-19	W-20	12"	1"	
4	EE 161060 - 161105	B-21288	6.9985" - 7.0000" & 6.9945" - 6.9960"	10.6562" - 10.6662" & 10.6562" - 10.6662"	2 3/8	2 3/8	2 3/8	4 3/8	T 511	D 15318	5.1175" - 5.1225" & 5.1175" - 5.1225"	3 5/8	1 3/8	861 - 854	A - 5476	6.4925" - 6.5025" & 6.4925" - 6.5025"	7.4990" - 7.5090" & 7.4990" - 7.5090"	2 5/8	1 3/8	1	4 3/8	4 3/8	4 3/8	AH-20	W-20	12 3/4"	1"	
5	HM 221075 - 221127	B-15134	7.3785" - 7.3795" & 7.3785" - 7.3795"	12.5591" - 12.5631" & 12.5591" - 12.5631"	2 3/4	2 3/4	2 3/4	4 3/4	T 611	C-13494	6.4925" - 6.5025" & 6.4925" - 6.5025"	4 1/8	2 1/8	86600 - 86930	B 8290	7.9925" - 8.0025" & 7.9925" - 8.0025"	9.8440" - 9.8540" & 9.8440" - 9.8540"	2 3/8	1 3/8	1	5 1/8	5 1/8	6"	AH-24	W-24	15 3/8"	1 1/2"	
6	LEA 28084 - 421451	C-12170	8.9985" - 9.0000" & 8.9985" - 9.0000"	12.5591" - 12.5631" & 12.5591" - 12.5631"	2 3/4	2 3/4	2 3/4	4 3/4	T 671	C-16336	6.4975" - 6.5025" & 6.4975" - 6.5025"	4 1/8	2 1/8	EE 230581 - 231512	B 11232	8.9925" - 9.0025" & 8.9925" - 9.0025"	11.1250" - 11.1350" & 11.1250" - 11.1350"	2 3/8	1 3/8	1 1/8	5 1/8	5 1/8	7 1/8"	AH-30	W-30	17"	1 3/8"	
7	HM 551092 - 551710	C-12936	10.0925" - 10.0965" & 10.0925" - 10.0965"	13.5011" - 13.5091" & 13.5011" - 13.5091"	3 1/8	3 1/8	3 1/8	5 1/8	T 811	C-13248	8.4965" - 8.5062" & 8.4965" - 8.5062"	5 1/8	2 5/8	EE 230751 - 231412	C 13161	9.5245" - 9.5370" & 9.5245" - 9.5370"	14.3750" - 14.3750" & 14.3750" - 14.3750"	2 5/8	1 3/8	1 3/8	6 1/8	6 1/8	9"	H-36	W-36	20"	1 3/8"	
8	EE 726120 - 726190	C-13136	12.9968" - 13.0000" & 12.9968" - 13.0000"	19.6846" - 19.6946" & 19.6846" - 19.6946"	4 3/8	4 3/8	4 3/8	7"	T 911	C 13962	9.8464" - 9.8562" & 9.8464" - 9.8562"	5 1/8	2 5/8	420801 - 421412	C 11939	9.5245" - 9.5370" & 9.5245" - 9.5370"	14.3750" - 14.3750" & 14.3750" - 14.3750"	2 5/8	1 3/8	1 3/8	6 1/8	6 1/8	9"	H-40	W-40	23 3/8"	2"	

FIGURE 5—Typical thrust block bearing mounting, using a flat thrust type tapered roller bearing.

outer races are mounted with a floating fit in the gear case. The bearing adjacent to the coupling on the high speed shaft and the two bearings adjacent to the couplings on the low speed shafts are fixed in the gear case so as to locate the gear shafts and carry any existing thrust loads. The opposite bearings are permitted to float and carry radial loads only. The same oil which is used on the gears is also used for lubricating the bearings. A circulating oil system is used and the oil is fed into the groove and oil holes in the center of the outer race. This oil is pumped through the bearing to both sides and is drained back into the case. To maintain a level of oil in the bearings and eliminate any possibility of the bearings running dry, due to failure of operation of the circulating oil system, plates are welded to the inside of the case to maintain the oil level to the desired height. Suitable closures are used to eliminate oil leakage and entrance of foreign matter at the shaft extensions.

To carry the loads encountered in the rerolling mills, four row tapered roller bearings are used on the roll necks. These bearings are ideally suited for this work since they carry thrust loads as well as radial loads. In other words, the passes in the rolls can be properly lined up and the set-up maintained until the passes have worn sufficiently to require remachining. The general arrangement of the bearings is shown in Figure 3. The bearings are mounted with a loose fit on the roll necks so that they can easily be changed from one roll to another. The inner filler ring is pressed on the roll necks and remains as a part of the roll until the roll is worn to its minimum diameter when the filler ring can be moved to a new roll. To reduce neck scuffing to a minimum, the inner races are clamped as shown between the hardened and lubricated faces of the inner and outer filler rings. Since the bearings are subject to frequent changes from one roll to another and the bearings and chocks may remain around without being mounted on a roll, special precautions are taken to assure that the bearings are properly protected in the chocks. The inner portion of the chock is designed in the form of a projecting lip which comes down close to the inner race of the bearing. The outer filler ring is designed with a projecting portion which can not get past the outer closure plate unless this plate is unbolted from the chock. In removing a bearing assembly from the roll the set screw in the clamping nut is taken out, the nut backed off and the chock, bearing and outer filler ring is removed as a unit. Due to the close clearances of the parts very little grease is lost and the possibility of foreign matter getting into the bearings is small.

To take care of the proper setting of the passes in the rolls, one of the chocks preferably on the bottom roll is designed with projecting ears which in cooperation with suitable push and pull nuts can move the roll in and out. The opposite chock does not have these ears and floats in the mill housing. On the top roll the chock directly over the adjustable bottom roll chock is fixed to the housing by suitable means. The opposite chock floats in the housing.

The application of the bearings on the reeling machine rolls is shown in Figure 4. It will be noted that the design is similar to that used on the main piercing rolls and the same procedure is followed in the handling

and machining of the rolls. In this design the keying of the inner races and filler rings is illustrated. It will also be noted that the bearing chocks are made spherical to take care of the alignment in setting of the rolls.

Since the rolls in the piercing mill are obliquely disposed in relation to the axis of the billet, they tend to rotate the billet and feed it forward over the mandrel. The mandrel being located on the same axis as the billet tends to prevent it from moving forward. This sets up a thrust load on the piercing mill rolls and on the thrust block to which the mandrel is attached. Tapered roller bearings of the standard design and of the flat thrust type are especially suited to handle the loads set up in the thrust block. Two typical designs have been worked out and satisfactorily used.

Figure 5 shows the use of the flat thrust type tapered roller bearing. At the nose of the spindle a two row floating radial bearing is used. This bearing carries the radial load set up by the overhang and whip of the mandrel. To reduce this load it is strongly recommended that the mandrel be attached to the thrust block through a spherical seat. The flat thrust bearing carries thrust load only. It is important that it be squarely and solidly backed. To maintain the proper set-up of the thrust bearing, a single row bearing is used at the far end of the block. This bearing also serves to carry the reverse thrust set up by the withdrawal of the mandrel from the pierced tube. Because of the heavy loads encountered and the high speeds of operation, the lubrication of all the bearings must be closely watched. Experience has shown that by maintaining a proper level of an extreme pressure quality oil best results will be obtained. To maintain this oil level and to exclude excess water and foreign matter, the closures shown have been adopted. Variations of these closures have also been used.

The design of thrust block shown in Figure 6 has also been used with success. In this design a steep angle radial thrust bearing is used instead of the flat thrust bearing. The other bearings serve the same function as in the previous design. The same method of lubrication is recommended.

The work done on the tube in the sizing mill is such that the loads set up can be handled on a two row tapered roller bearing. Figure 7 shows a design which has been satisfactorily used. Since the bearings are mounted with a loose fit on the roll necks it is preferred that they be clamped between the filler rings as shown in order to reduce scuffing. However, there are some mills in operation where the bearings are not clamped on the roll necks. In order to obtain proper pass adjustment, a scheme similar to that discussed in connection with the rerolling mill is used. On each roll at one end a floating chock is used. At the opposite end of one roll the chock is bolted or otherwise fixed to the mill housing. On the other roll an adjustable chock is used.

Some sizing mills are designed with overhung rolls as shown in Figure 8. In this design the load on the bearing adjacent to the roll is usually such that a four row bearing is required. To permit using a minimum diameter roll and at the same time obtain a maximum bearing capacity, the bearing adjacent to the roll is permitted to float. The thrust load set up by the grooved rolls is carried on the bearing at the opposite end of the shaft. This bearing also carries its portion

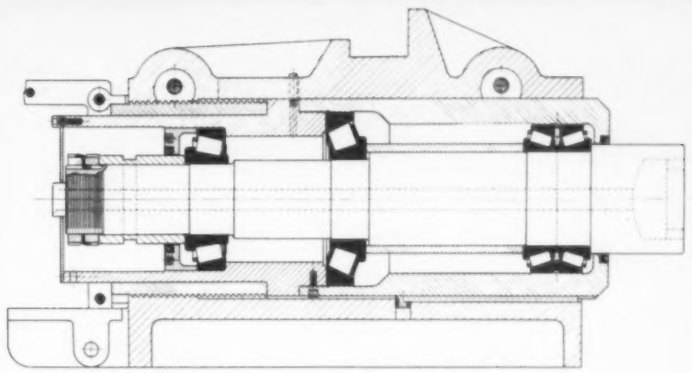


FIGURE 6—Another design of thrust block bearing mounting, using a steep angle radial thrust bearing.

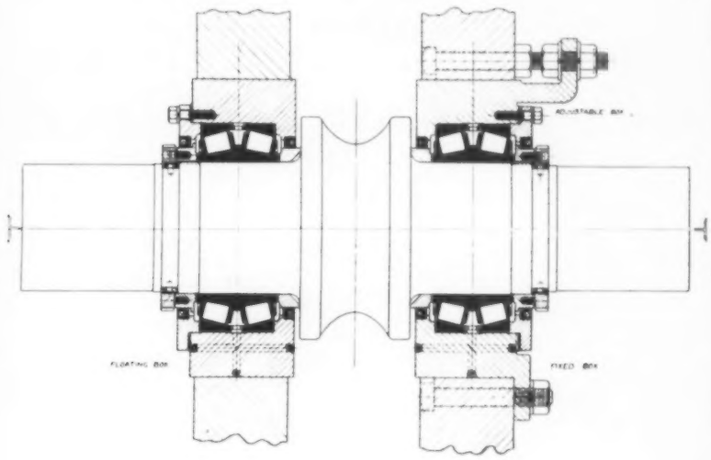


FIGURE 7—Sizing mill loads are such that they can be handled on a two-row tapered roller bearing.

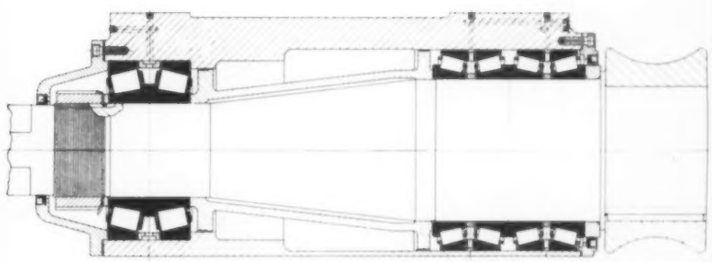
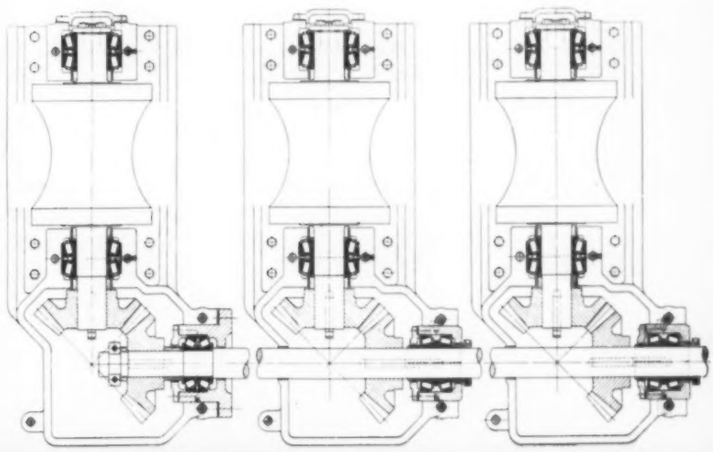


FIGURE 8—Loads on the bearing adjacent to an overhung sizing mill roll may necessitate the use of a four-row bearing.

FIGURE 9—Bearing application on tube mill table rollers is practically the same as on standard mill tables.



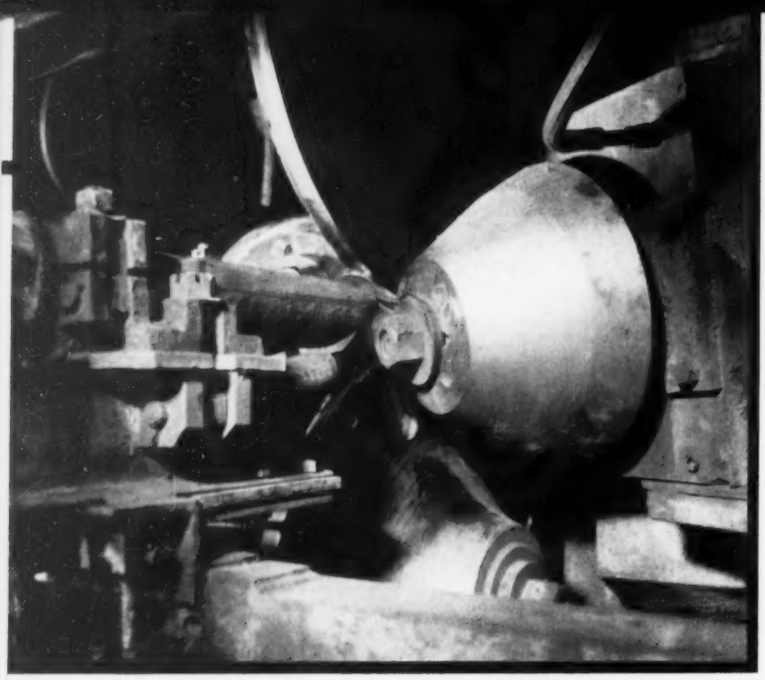


FIGURE 10—View of the overhung rolls in a piercing mill in the Diescher process.

of the radial load. Since the bearings do not have to be removed for roll changes they are fitted tight on the shaft and thus all possible creep and scuffing is eliminated.

The bearing application on the table rollers used to convey the tube is practically the same as that of standard mill table rollers. In Figure 9 a two row bearing is shown fixed in the housing adjacent to the bevel gear. The opposite end of the roll is mounted on a similar two row bearing which floats in the housing. The line shaft is fixed at one point, to carry all the bevel gear thrust loads, by means of a two row steep angle bearing as shown in the lower left hand position. Adjacent to the other bevel gears, unit bearing assemblies are used. These units are purchased complete with sleeves which can be clamped on the shaft at the desired position. All these units float in the main housing so that they carry radial loads only. All of the bearings on the table rollers are enclosed and grease lubricated either manually or from an automatic system.

DIESCHER PROCESS

In the Diescher process the billet is pierced in the piercing mill and then conveyed to the "elongator" which replaces the usual rerolling and reeling operations of the conventional automatic or plug mill. After leaving the elongator the tube may be further reduced in diameter by running it through a sizing or sinking mill.

A more detailed description of the process as given by the originators is as follows:

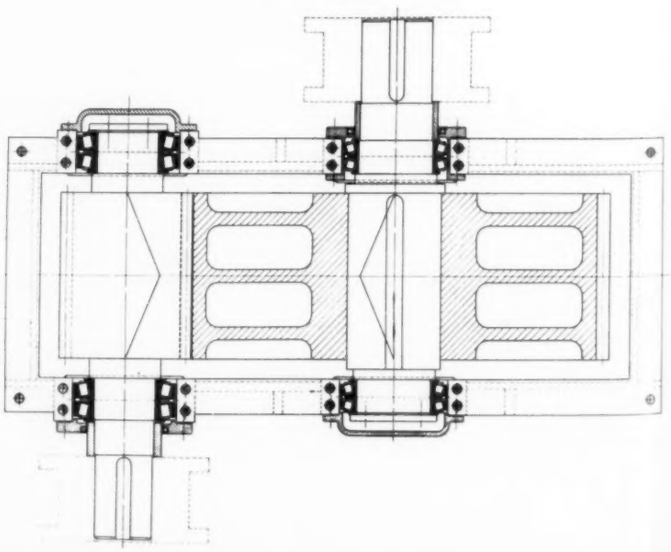
In the practice of the Diescher elongator, a tubular blank is reduced in wall thickness, and elongated, by subjecting the blank, while on a floating mandrel, to the reducing action of a pair of cross or equivalent helically-acting rolls. The tubular blank is permitted to take a cross-sectional form in which it bulges laterally from those portions of the surface of the mandrel that lie between the oppositely disposed points of engagement of the cross rolls with the blank. The reducing pressure of the cross rolls on the blank causes the metal to flow from the pressure points, and, considered as to its peripheral and longitudinal components, such flow is predominantly peripheral.

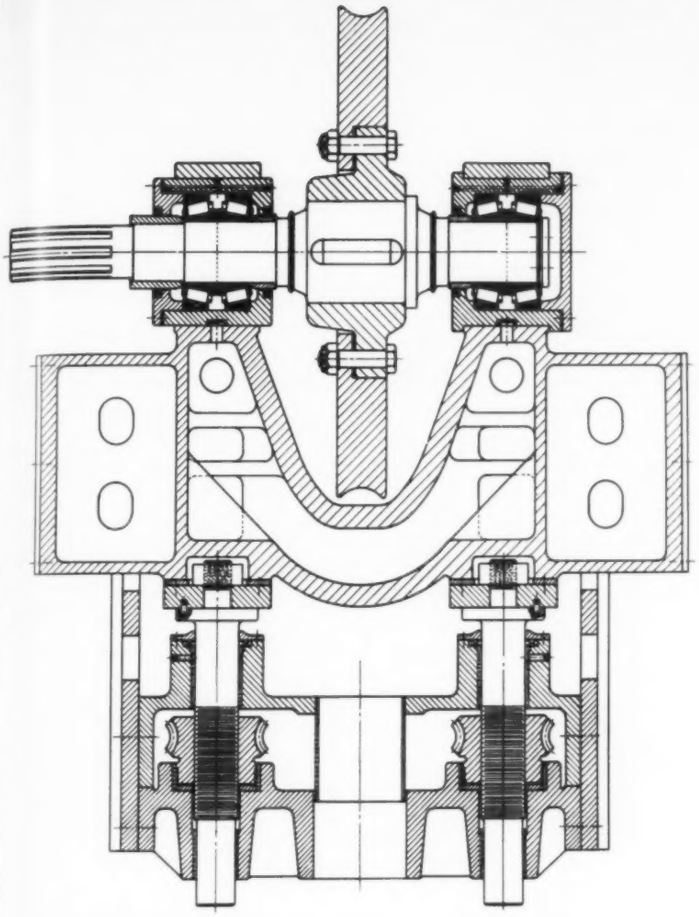
Simultaneously with such reduction, the lateral bulging of the blank is limited and peripheral flow of the metal is controlled (being diverted longitudinally of the blank, that is, converted into a flow having a larger longitudinal component) by a pair of driven grooved guide discs. These are arranged between the cross rolls in such a manner that their surfaces act upon the exterior of the blank at the portions thereof which have been caused to bulge laterally from the surface of the mandrel. At its point of reduction, the blank assumes a cross section having a larger interior circumference than the circumference of the mandrel, the bulging form of the blank being much less, however, than it would be if the lateral bulging were not limited by the guide discs. As the elliptically-shaped blank or tube moves forwardly from its point of reduction, it is progressively converted into truly cylindrical form by the action of outwardly flaring faces of the cross rolls.

The application of guide discs may also be used in piercing mills, said application tending to produce more uniform walls in pierced blanks. The use of guide discs in piercing mills aids materially in pulling the workpiece through.

Tapered roller bearings have been very successfully used in the Diescher process and a few of the outstanding applications will be shown. In connection with these applications a tube piercing mill with overhung rolls is shown in Figure 10. In applying bearings to piercing mill rolls of this type the same principles are followed as in the case of the overhung sizing mill roll discussed in Figure 8. A four row tapered roller bearing is used adjacent to the roll, but in this case is mounted in a chock which is permitted to float in the main housing. The thrust load generated by the rolls during piercing is carried by a two row steep angle bearing at

FIGURE 11—Typical bearing application in a single reduction herring-bone gear unit.





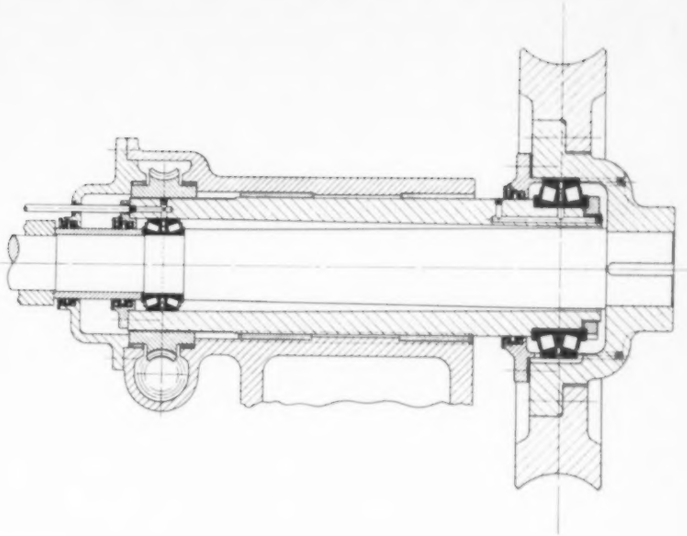


FIGURE 13—Alternate guide disc bearing mounting with bearing mounted directly on the disc.

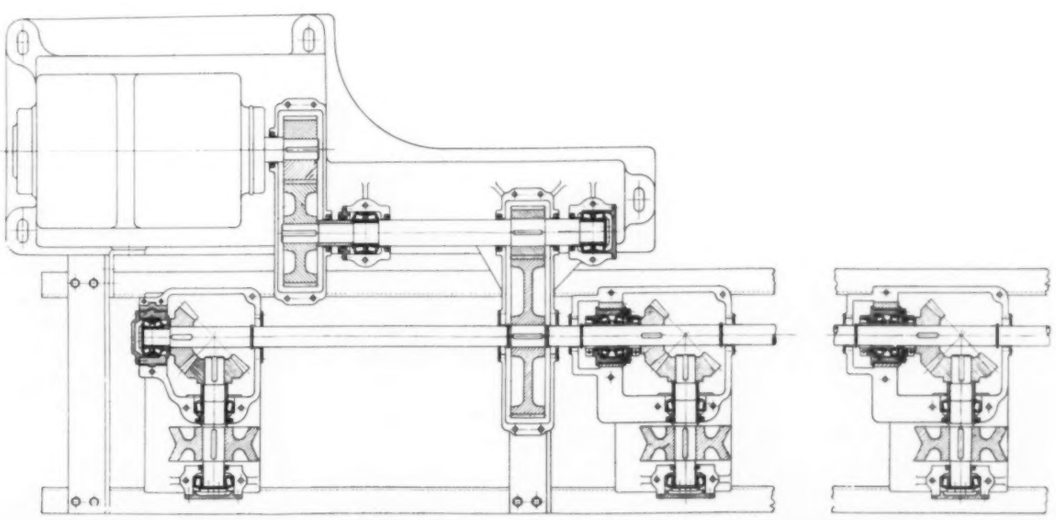
FIGURE 12—Guide disc bearing mounting of line shaft design, with grooved disc attached to hub pressed on shaft.

the opposite end of the shaft. Here again the bearings are mounted with a press fit on the roll shaft.

The mounting of the main rolls used in the elongator is similar to that shown in Figure 4, with the exception that two row tapered roller bearings having one piece inner races are used at each end of the roll. The bearings are mounted loose on the roll necks and clamped between the spacers which have hardened faces slotted for lubrication. The bearings are mounted in self-aligning chocks. One bearing on each roll is fixed in the chock and the opposite bearing is permitted to float. To reduce the scuffing of the bearings on the roll necks the bores of the bearings may be lubricated by proper drilling of the necks.

A typical single reduction herringbone gear unit is shown in Figure 11. In this design one bearing on the low speed shaft is fixed in the housing while the remaining bearings are permitted to float. A circulating oil system is used on the bearings. Proper provision is

FIGURE 14—Typical bearing application on elongator mandrel feed table rolls and drive.



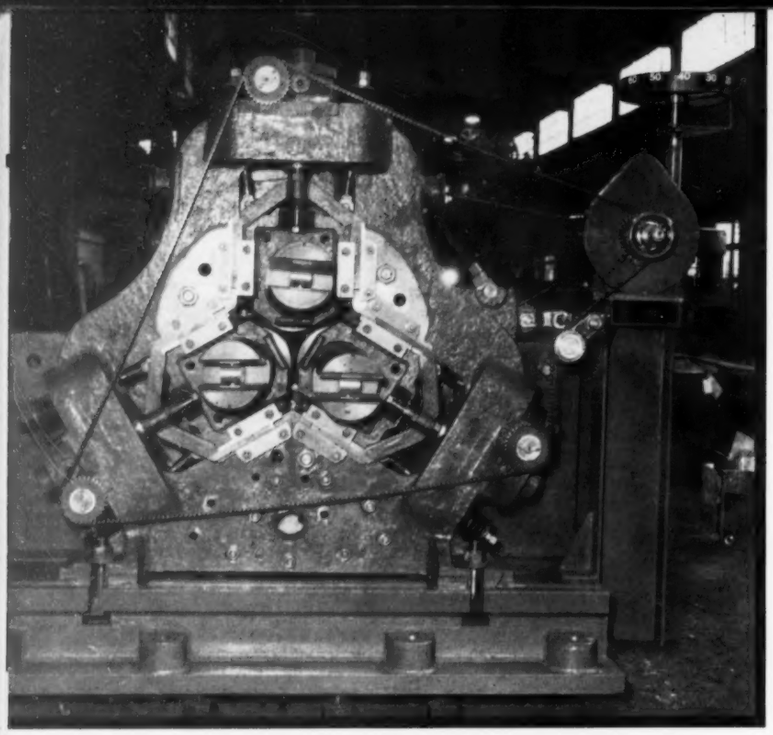


FIGURE 15—End view showing roll arrangement in the sizing mill in the Assel process.

made to maintain an oil level by means of plates welded on the inside of the case.

For the guide discs two alternate designs are shown. Figure 12 shows a live shaft design where the grooved disc is attached to a hub which is press fitted on the shaft. Two single row bearings mounted back to back are used at each end of the shaft. The bearings are mounted in chocks one of which is floating in the housing and the other is fixed to the housing. The fixed box can be made adjustable to provide for lining up the grooves in the discs. Adjustment may also be made by means of split shims between the disc and hub.

A second design using the bearings mounted direct in the disc is shown in Figure 13. The disc is attached to a hub which is keyed to the driving shaft. The outer race of the bearing is press fitted in the hub while the inner races are mounted on a stationary sleeve which is adjustable endwise by means of the threaded worm wheel. This provides for the proper setting of the discs. Lubrication for the drive shaft bearing and for the disc bearing is provided by proper drilling of the sleeve as shown.

The application of the bearings on the elongator mandrel feed table rolls and drive is indicated in Figure 14. The driven roll is mounted on single row bearings on either side of the roll. The bearing adjacent to the bevel gear is lubricated from the oil in the gear case. The bearing at the other end is grease lubricated. On the line shaft a unit bearing assembly mounted on a sleeve is used at each gear except the extreme end where a steep angle two row bearing is fixed in the housing so as to locate the entire line shaft. The other bearing blocks are permitted to float. Provision is made for the easy disengagement of the line shaft bevel gears by means of the special filler piece which is used with each box. The removal of this filler permits of lifting the gear out of mesh. On the drive shaft which drives the line shaft two row bearings are used in each box. In one box the bearing is fixed while in the other it is permitted to float.

THE ASSEL PROCESS

The Assel process was developed after considerable investigation was carried on to obtain a mill to suit the conditions peculiar to the Timken requirements. These requirements were a wide range of sizes, varying by a few thousandths in diameter and wall. After three years of experimental work, a mill was installed in 1935 at our Wooster plant. Mr. Assel describes this mill as follows: The mill equipment consists of a furnace, a 17-inch piercing mill, three roll elongating mill and a three roll sizing mill. The elongating mill and sizing mill are both cross rolling mills. The tube diameter as well as the wall thickness is reduced in the elongating mill. The wall thickness can be controlled very accurately at the elongating mill, while the accurate diameter is obtained at the sizing mill. Figure 15 shows an

FIGURE 16—On the Assel elongator rolls, the coupling end bearing is fixed in the chock, while the other floats.

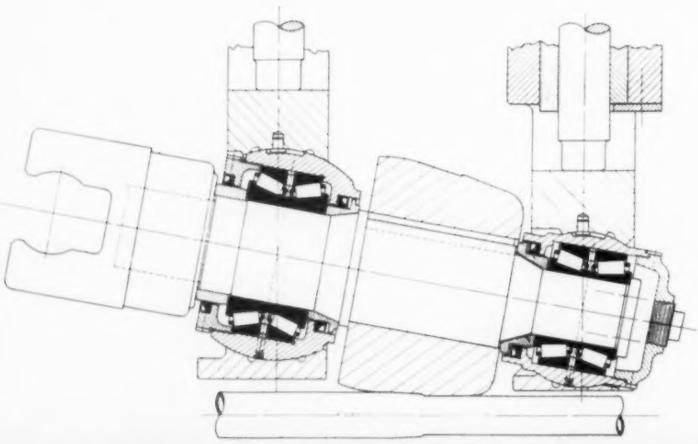
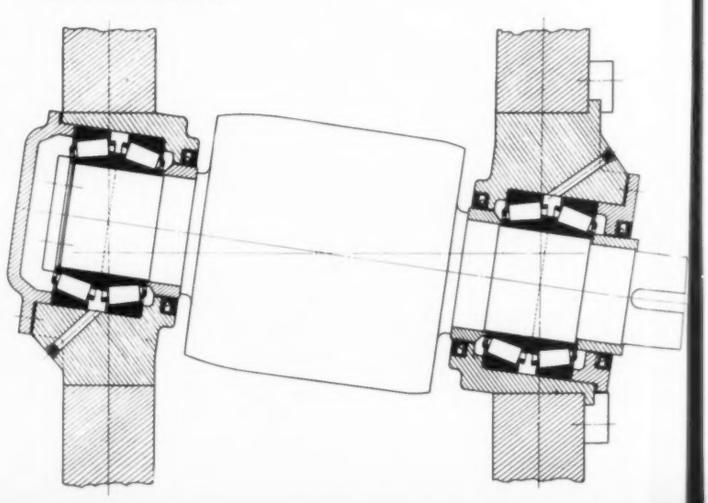


FIGURE 17—In the Assel sizing mill, both bearings are fixed in chocks, one of which is fixed in the housing, the other floating.



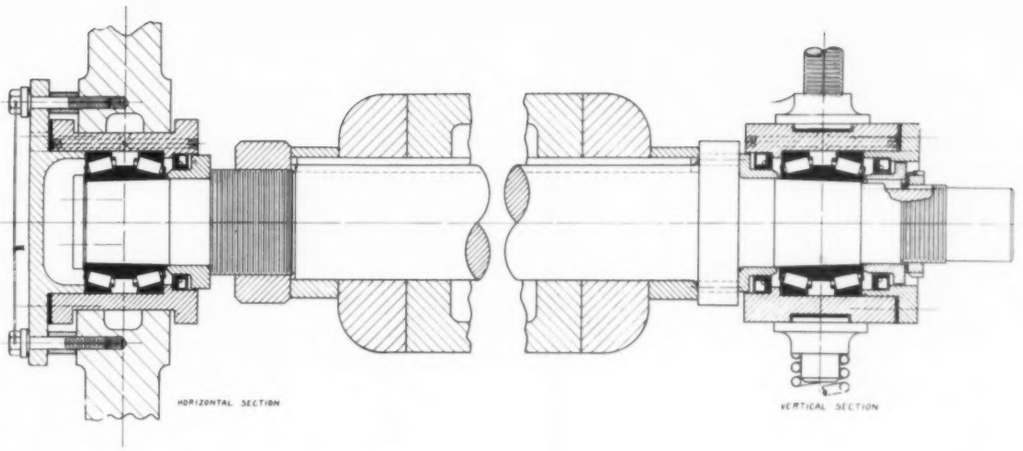


FIGURE 18—General arrangement of a forming roll assembly for a welded tube mill, showing bearing application.

end view of the roll arrangement in the sizing mill. Outstanding features of this mill are:

1. Flexibility. Sizes from 1¾ inch to 3 inch diameter and walls from .187 inches to .950 inches are produced on the same set of rolls. In making a size change, the gauge setting of the mill rolls is adjusted and the mandrel bars are changed. As many as 15 order changes have been made in 16 hours.

2. Accuracy. The mill is scheduled for plus or minus .010 inches on the diameter and plus or minus 5 per cent on the wall thickness. Due to the ability to control tolerances, a lighter average tube is produced, resulting in increased footage.

3. Absence of mill guides. The use of three rolls makes the mill self-centering and eliminates the possibility of guide scratches.

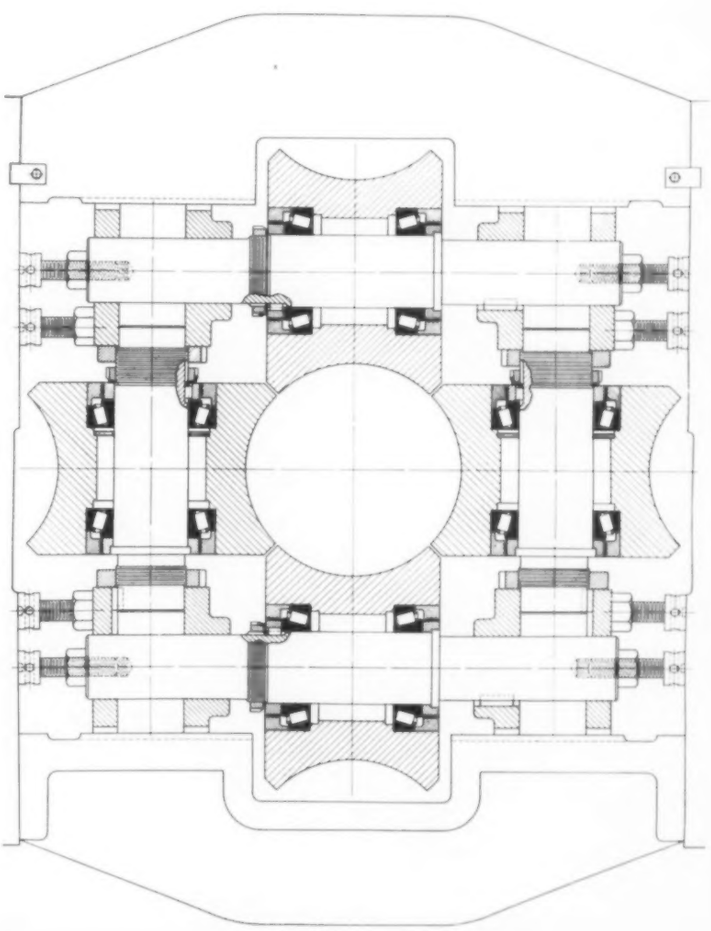
4. Large reductions. Reductions of 5 to 1 in section have been made, reducing a billet from 3 inch diameter by .456 inch wall to 2.125 inch diameter by .114 inch wall. We do not make such light wall material normally, therefore, do not often make reductions as large as this.

The mounting of the bearings on the elongator and sizing mill rolls is illustrated in Figures 16 and 17. On the elongator rolls the two row bearings are mounted in self-aligning chocks. The bearing at the coupling end is fixed in the chock while the opposite end bearing floats in the chock. The bearings are mounted with a press fit on the roll neck, proper provision being made for their removal when roll replacement is necessary. On the sizing mill rolls both bearings are fixed in the chocks. One chock is fixed to the housing while the other chock floats in the housing.

WELDED TUBES

The manufacture of welded tubes differs from the seamless process in that the tube is formed from flat strip and welded. To obtain a round tube the strip is conveyed through a number of stands each carrying two or more rolls. These rolls are of different curvatures so that as the strip passes from stand to stand it is gradually formed into a round tube. After going through the last stand of rolls it passes on to an auto-

FIGURE 19—Arrangement of welded tube mill idler roll cluster, designed to keep pipe straight entering the welding unit.



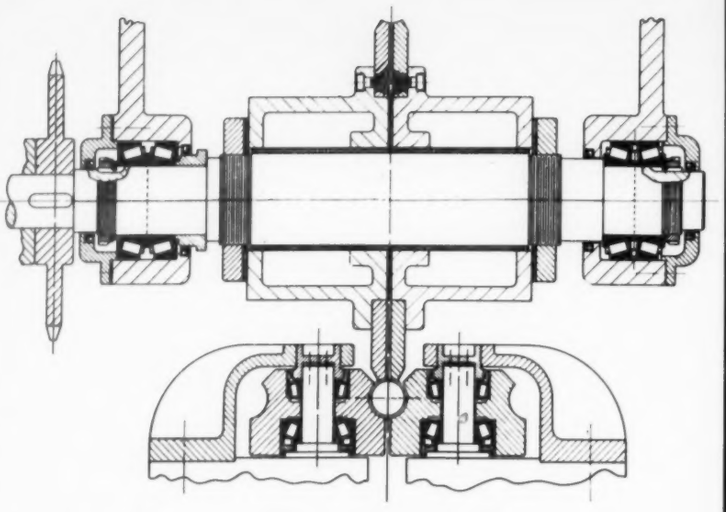


FIGURE 20—Typical design of the welding roll in an electric weld tube mill.

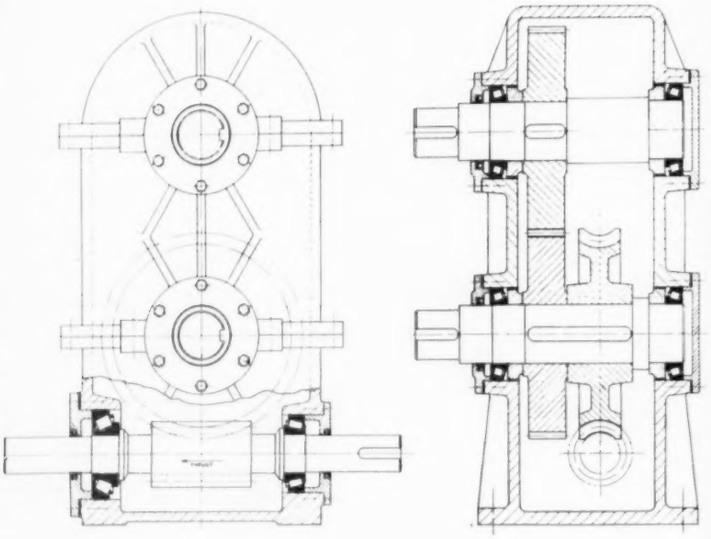
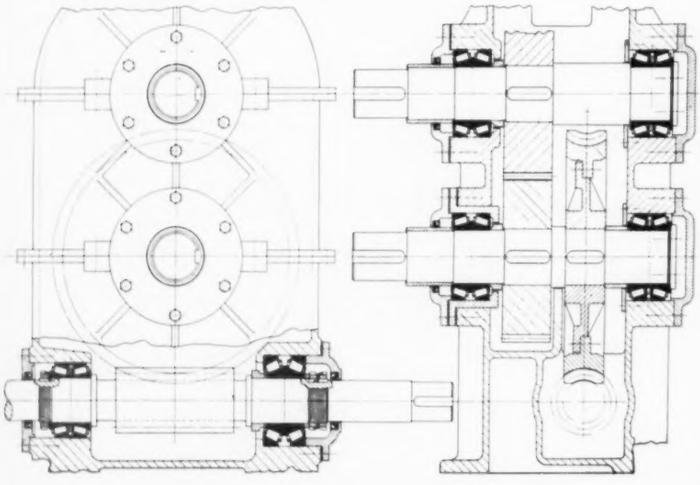


FIGURE 21—Single-row bearings are used on roll drives of welded tube mills for smaller size tubes.

FIGURE 22—In larger size welded tube mills, double-row bearings are applied on the roll drive.



matic welder where it is welded. Different methods of welding have been successfully used.

Due to the variation in tube sizes which may be made on a given mill, it is necessary to have a large number of forming rolls. To reduce the cost to a minimum, the rolls are designed so that they can be assembled on a suitable arbor. The general arrangement of a welded tube mill roll assembly is shown in Figure 18. The shaft or mandrel is usually made with a shoulder against which by means of proper filler rings the shaped roll is assembled and clamped in place with a nut. A double row bearing is used at each end of the shaft. The bearing is made with a tapered inner race so that the assembled bearing and chock can be easily removed when a roll change has to be made. In this particular design the nut which is used to hold the roll in place can be backed off and used to remove the bearing. The bearings at both ends of the roll are made the same in order to reduce the number of spare bearings and chocks to be carried. The general design of the chocks is the same except that at one end of the roll the bearing adjusting cap is made with long ears which serve as a means of providing adjustment for the matching of the curvature of the rolls.

To keep the pipe straight before entering the welding unit it usually passes through an idler roll cluster similar to that shown in Figure 19. These rolls are mounted on stationary shafts and supported on single row tapered roller bearings which handle both the radial and thrust loads. It will be noted that proper provision is made on each shaft for the adjustment of the roll to match the other rolls in the cluster.

A typical design of a tube welding unit is shown in Figure 20. The mounting of the welding roll is similar to that of the other driven rolls in that provision is made for easy disassembly of the bearings and replacement and adjustment of the welding roll. While the tube passes through the welder it is supported by the vertically mounted idler rolls shown. These rolls are similar in general arrangement to the idler cluster rolls previously described.

Two typical welded tube mill roll drives are shown in Figures 21 and 22. Figure 21 shows a drive used in mills working on smaller size tubes. Here single row bearings are used on all shafts. The setting of the worm and worm wheel is obtained by means of shims as is also the adjustment of the bearings. The worm shaft bearings are oil lubricated. The bearings on the other two shafts are sealed off from the case and are grease lubricated.

A typical drive for the larger size mills is shown in Figure 22. Here double row bearings are used at each end of each shaft. One end of each shaft is fixed while the other is permitted to float. To obtain proper setting of the worm and wheel the bearing at the extension end of the worm wheel shaft is mounted in a cartridge which can be moved in or out by varying the thickness of the shims between it and the case. All the other bearings are mounted direct in the case. As in the previous drive, the worm shaft bearings are oil lubricated and the other bearings grease lubricated.

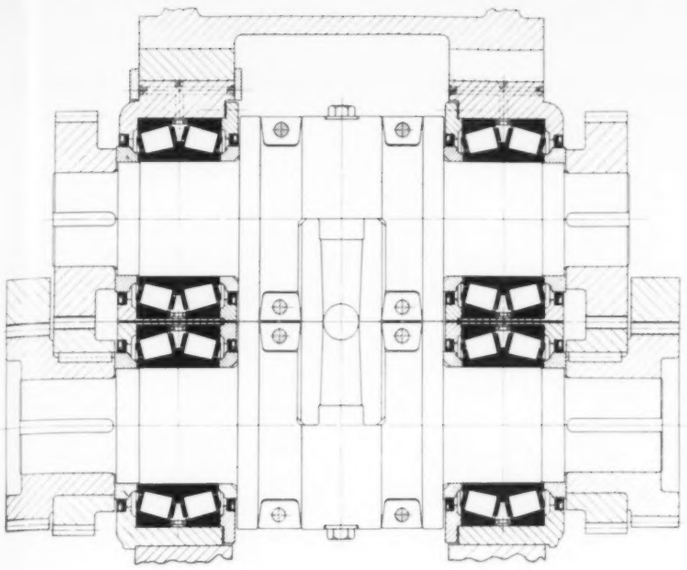


FIGURE 23—General arrangement of bearings on main rolls of cold tube reducing machine.

AUXILIARY EQUIPMENT

For the proper finishing of the tubes various means are employed and equipment of various types is used. It will be impossible in this paper to cover all this equipment and its bearing requirements. Consequently only a few pieces of equipment which may be considered of major importance from a bearing standpoint will be discussed.

For the cold reduction of seamless tubes a number of mills have installed the Neuberth tube reducing machines. The work done by these machines is such as to subject the bearings to severe loads. Figure 23 shows the general arrangement of the bearings on the main rolls of one of these machines. Heavy duty two row bearings are used at each end of the roll. The dies are attached at the center of the rolls and the bearings need not be removed from the rolls except in case of roll breakage or bearing failure.

A typical tube mill swing saw design is shown in Figure 24. All of the bearings are mounted in self-aligning housings. One bearing in the main frame and one bearing in the swing frame are fixed, the opposite bearings are permitted to float. Due to the high speed of operation of the saw, the bearings are set up by means of spacers ground to give the required running clearance. The cup spacer is machined so as to direct the lubricant to each bearing. Rubbing seals of the type shown are used on the smaller saws. On the larger saws, properly designed labyrinth seals are used.

Tube straighteners of various designs are used to properly straighten the tubes. A typical straightener drive and roll arrangement is shown in Figure 25. Two row bearings are used on all shafts to take care of the radial and thrust loads set up by the gears, the angularity of the shafts and the straightening loads. One bearing on each shaft is fixed to carry the thrust loads. The remaining bearings on each shaft are permitted to float. All the bearings are grease lubricated. To obtain the load capacity required to straighten many kinds of stock, it is frequently necessary to use a four row bearing because of restrictions on roll diameters.

The preceding designs were selected to illustrate the various bearing combinations used to handle the loads and operating conditions. Similar arrangements are used on the other pieces of equipment which have not been individually discussed.

FIGURE 24—Bearings for tube mill swing saws are mounted in self-aligning housings.

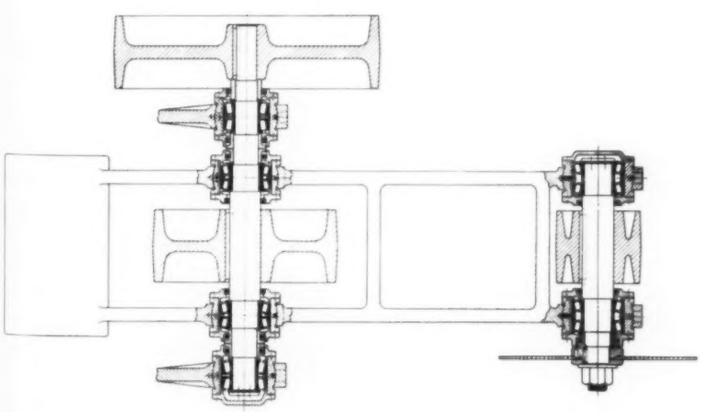
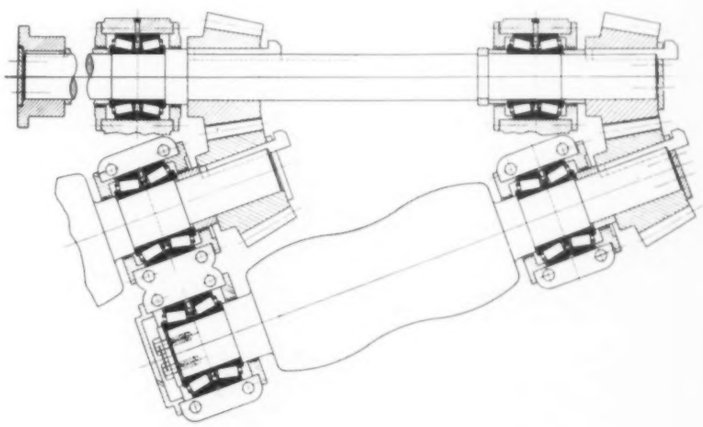


FIGURE 25—Typical straightener drive and roll arrangement, used for straightening the finished tube.



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▲ IN discussing the trends of the problems involved in insulation practice of electrical apparatus and machinery, it is first necessary to understand the functioning of an insulating material and to consider the nature of the insulating material itself, both physically and chemically. With an understanding of these, the logical developments of insulations up to the present time and some predictions of future possibilities can be considered.

All matter to a more or less extent possesses the property of electrical conduction. That which conducts electricity freely, without undue restriction, such as most metals, is known as a conductor. Those conductors which retard to a more or less extent the flow of electricity are known as resistors. The materials which stubbornly oppose the passage of electric current through themselves are called insulators. No matter is a perfect conductor of electricity for if it were, a current of electricity could continue to flow without an impressed electro-motive force and there would be no loss in the transmission of electric power. Neither are there any perfect insulators in the sense that they can absolutely prohibit the flow of electric current.

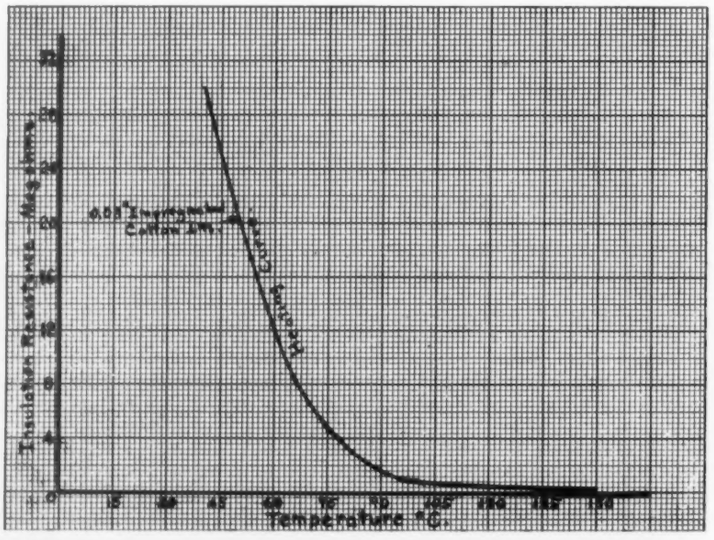
Physicists have explained conduction in gases by the electronic theory on the assumption of the existence and motions of infinitely small electrically charged particles called ions, which are considered to consist of atoms or groups of atoms, or of very much smaller negatively charged particles known as electrons. It is further assumed that every atom has associated with it one or more free electrons, whose total negative charge is balanced by an equivalent positive charge on the atom and that an ion possessing a definite positive or negative charge is formed by the addition of an electron to, or its removal from, one of these neutral atoms or combinations of atoms.

When the force between the atoms and their electrons is overcome, the free ions thus formed can move when they are under the influence of an electro-motive force. These ions in motion in a definite direction constitute an electric current, the magnitude of which is determined by the number of ions and the velocity with which they move as fixed by the value of the applied electro-motive force.

This process of the conduction of electricity is the same for all matter, be it of a solid, liquid or gaseous form. However, in different materials it differs in magnitude. The better the conductor, the weaker the cohesive force between the atoms and their electrons, so that there is always a large number of free ions to easily convey the flow of electric current. In other words, a low value of electro-motive force will set in motion a large flow of ions, causing a current flow of large magnitude. The converse is true for insulators.

When a difference of potential or electro-motive force is applied to the two ends or sides of an insulator or dielectric, a stress is set up in the dielectric, the intensity of which depends upon the applied potential, the size and shape of the electrodes and the distance between them. This stress tends to distort the molecular structure of the insulating medium and liberates perhaps a small number of electrons which, together with any existing ions, flow in the direction of the lines of applied electro-motive force through the inter-atomic space of the material with a velocity depending upon their mass, charge and strength of the field. As long as the current flow is small, it is proportional to the applied voltage, which means that the resistance to the motion of the ions is constant. When, however, the applied voltage is increased to a sufficiently high value, the resistance to ionic current flow is no longer constant, the insulating or dielectric material is said to have broken down and it no longer resists to a high degree the flow of current and a new and very much increased

FIGURE 1—Curve of insulation resistance vs. temperature for impregnated cotton insulation .03 in. thick.



INSULATION Practice

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current flow occurs, corresponding to the resistance to ionic current flow of the material in the punctured hole in the dielectric (usually air). The property possessed by the insulating material to resist this disruption to its normal ionic current flow and the disruption of its normal ionic current flow and the disruption of its molecular structure is known as dielectric strength.

Before breakdown, the small current flow in the dielectric causes distortion of the structure of the dielectric material and this displacement or charging current is the condenser current flow, the magnitude of which depends for a given area of electrode and thickness of dielectric upon the property of the material known as its specific inductive capacity.

When the applied potential is direct electro-motive force, the molecular disturbance is in one direction and remains in this one direction as long as the potential is applied. If an alternating electro-motive force is applied, the molecular disturbance is first in one direction and then reverses in the other direction with the applied frequency. The energy required to alternate this disturbance results in a heating of the dielectric. This loss is known as the dielectric loss or frequently as the dielectric hysteresis.

In conductors such as metals, the resistance to ionic current flow is constant and there is no breaking down of the material in the same sense as in the case of dielectrics. However, if too heavy a current flow is caused by too great an applied electro-motive force, the resistance to ionic current flow in the conductor may cause a generation of so much heat loss as to cause the melting of the conductor at the point of greatest heat generation per unit volume of material. This can result in a separation of the conductor, an ionized arc current flow and eventually an opening of the circuit.

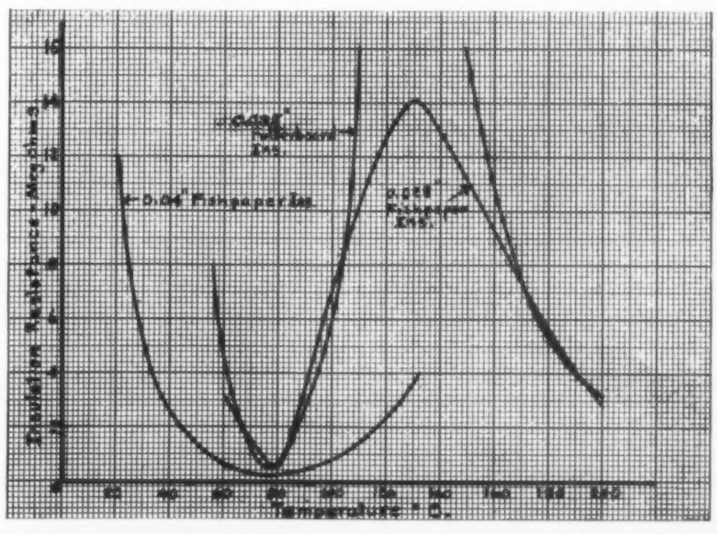
The difference between an electric conductor and an insulator or dielectric is readily understood in light of the above discourse.

The resistance of a non-conductor or dielectric, which for the remainder of this paper will be known as an insulator or insulation, is affected by temperature and moisture. Figure 1 shows the change of insulation resistance with temperature of a piece of 0.03 in. thick impregnated cotton insulation. The insulation resistance decreases rapidly as the temperature increases, with a minimum value of 150 degrees C., for this particular material. Figure 2 shows similar curves on untreated fibrous materials, papers and fullerboards. For these untreated materials, after the insulation resistance dropped to a low value with an increase of temperature, a further increase of temperature gave an increase in resistance, due mainly to the expulsion of moisture from the fibres. As the temperature is still further increased, the materials begin to carbonize and behave as high resistance conductors. Further temperature carbonization reduces the insulation resistances rapidly to low values.

These two sets of curves show the general tendencies of insulation materials, but the actual temperatures for minimum values of resistances depend upon the amount of moisture present, the chemical and physical changes that occur due to temperature and to the area of the electrodes and resulting conduction current. Thus, although insulation resistance is a measure of the conduction current that can flow, it does not give an indication of the breakdown voltage necessary to cause failure of the insulation.

The following factors affect the breakdown voltage of insulation: heating either internal or external, chemical change, absorption of moisture and the nature of surrounding material. The dielectric loss in the insulating material subjected to an alternating electro-motive force results in internal heating of the material. Since all electrical insulating materials are also poor

FIGURE 2—Curves of insulation resistance vs. temperature for untreated fibrous materials, papers and fullerboards.



heat conductors, the localized heating may carbonize portions of the insulation before the heat can be dissipated to the surface. The dielectric loss increases with temperature. Thus, with the addition of external heat, such as produced in the insulated conductors of an electrical machine, the voltage required to produce a breakdown of the insulation will be much less when the insulation is hot than when it is cold. Thus the necessity for eliminating hot spot temperature in insulation is apparent.

Figure 3 shows the increase in dielectric loss with time for different voltages applied to varnished paper insulation. It should be noted for this particular insulating material how the loss increases rapidly after a given time as the voltage is increased. With lower voltages, stable conditions are reached ultimately. Figure 4 shows the variation in loss with frequency of an applied constant electro-motive force at different temperatures in certain fibrous insulations.

Intense electrostatic fields as in high voltage apparatus can cause chemical changes in insulation where air pockets are present, when the voltage across them is high enough to produce a discharge. The products of this electric discharge may be ozone, oxides of nitrogen, nitrous or nitric acid and result generally in oxidation. On untreated cellulose material this results in disintegration and destruction of the fibrous materials. Oils and impregnating gums are oxidized and yield organic acids. Mica itself is unaffected but the shellacs or other binders used in forming built-up mica may be attacked.

Moisture in insulation provides a better conducting medium, resulting in greater heating due to the higher conduction current. If the moisture can escape and localized heating is not too rapid or great, the heating can dry out the insulation, resulting in increased insulation resistance, particularly after the machine cools down. If the heating is very rapid, carbonization of the material may occur due to moisture conduction and failure will result. Figure 5 shows the temperatures resulting in a fibrous insulation between conductors with time, for different voltages before and after drying. The temperatures are a measure of the conduction currents flowing.

The nature of the surrounding material affects the breakdown voltage, as the shapes of the conductors (or conductor and material at ground potential) determine the form of the electrostatic field around the insulation. Particularly is this true when machines or apparatus are subjected to over-potential tests. With sufficiently high testing potentials, a corona discharge will occur over the edges of the insulation or around the edges of overlapped tapes or wrappers, particularly mica, which materials greatly resist direct puncture. This discharge will in a relatively short time heat the material over which the discharge occurs and cause progressive failure to breakdown through the insulation.

It should be noted that in all these cases the element of time is all important, especially at potentials near the breakdown point of the particular insulation and for that reason, time limits are set on over-potential insulation tests.

TABLE I.
INSULATION CLASSIFICATION BY TEMPERATURE LIMITS

Class	Material Classification	Limiting Temperatures °C. For Industrial Apparatus		
		Thermometer	Imbedded Detector	Hot Spot
O Untreated Organic	Untreated fabrics, cotton silk linen, paper, press board, timber and cork and artificial cellulose products	80	90	95
A Impregnated Organic	Oil, varnish or wax treated or impregnated fabrics, cotton, silk, linen, paper, press board, timbers, vulcanized fibres, varnished paper and cloth products of the laminated-phenol-formaldehyde class, enamelled wire, organic bonds and moulded compositions with organic fillers or binders	90	100	105
B Impregnated Inorganic	Asbestos, built up mica, glass fabric, oxide films, non-ignitable boards and mouldings, moulded compositions made with non-organic fillers and bonds, slate and marble	110	120	125
C Fireproof and Refractory	Block mica, ceramics, steatite soap-stone, etc., and moulded compositions of mica, asbestos, etc., as fillers, using a vitreous binder	No limits specified.		

Since insulation has a resistance to current flow, this resistance can be measured and the measurements so obtained used as somewhat of a yard-stick in measuring the effectiveness of the insulation to ultimate failure. The insulation resistance is not a true measurement of the ability to resist breakdown for the various reasons already stated in this paper as affecting failures of insulation. It is, however, the best available means of determining the condition of the insulation in an electrical machine or apparatus. Four common methods are used for measuring insulation resistance: (1) the Wheatstone bridge method; (2) the insulation resistance meter or megger method; (3) the voltmeter method which requires an outside source of direct current, usually of 500 volts, and a voltmeter of known resistance; and (4) the volt ampere method requiring a reasonably high voltage direct current supply, a voltmeter and low reading ammeter, to measure the actual dielectric current flowing with the given impressed voltage. The resistance is obtained by applying Ohm's law.

Low insulation resistances are usually caused by oil and dirt or carbon accumulations on the surface of the insulation, or oil penetration of the insulation, or moisture in or on the surface of the insulation, or creepage surfaces. Removal of the causes by cleaning or baking respectively will generally restore the insulation to a safe resistance value.

Most insulation applied to electrical machinery conductors is not homogeneous material, nor is only one kind of insulation used. For instance, conductor insulation may be of cotton or asbestos while coil insulation may be of mica and a cotton or asbestos binder, treated or untreated, may be used. These different materials have different specific inductance capacities. In other words, for a given voltage they have different conduction currents per unit of thickness. If all the different insulations are concentric as they usually are, approximately the same current per unit area must flow through the different insulations (since they are in series to the conduction current flow). Thus the voltage stress will be distributed inversely proportional to the condenser capacity effect of the different insulating materials. For high voltage apparatus and machines particularly, the thickness of each different insulation material must be such that it will withstand the voltage stress to which it is subjected due to the condenser effect. Each different insulating material can be thought of as the dielectric of a condenser and the total thickness may be considered as so many condensers in series between the different insulated conductors or between the conductors and ground. Since the condenser capacity is proportional to the specific inductive capacity of the insulation divided by its thickness, the voltage borne by any layer will be proportional to the thickness divided by the specific inductive capacity of the material. By using a greater thickness of any one insulating medium, that insulation can be made to take the greatest portion of the total voltage stress.

Since temperature of operation of insulation is all important, this is the limiting criterion for insulation application and was so recognized early in the manufacture of electrical machinery. If it were not for this limitation, sufficient insulation to withstand the voltage requirements would be used and the entire machine would be operated at as high temperature as other considerations would permit. Since limitations must be placed on the temperature operation of insulation, limitations must also be placed on parts of machines adjacent to the insulation, that is, the magnetic cores, etc.

Insulations fall naturally into several classes, depending upon their abilities to withstand temperature before disintegrating or failing, thus no longer performing their function of limiting conduction currents to extremely low values. Four classes of insulation are recognized in regard to their temperature limitations, as indicated in Table I.

Insulations may also be classified according to their physical characteristics, as given in Table II.

Most of the insulating materials used are of an or-

TABLE II.
INSULATION CLASSIFICATION BY PHYSICAL CHARACTERISTICS

Solids	Natural	Gums and resins, asbestos, wood, soapstone, slate, marble, lava and mica.
	Fabricated	Papers and sheets, fabrics and yarns, hard rubber, synthetic resins, moulded compositions, glass and vitrified materials.
Plastics		Caoutchouc, gutta-percha, pitches, asphalts, waxes and compounds.
Liquids	Non-solidifying	Mineral oil, animal oil, and vegetable oil.
	Solidified on Application	Varnish, shellac, paint, enamel and japan.
Gases		Atmospheric air, hydrogen, nitrogen, and carbon dioxide.

ganic nature, originating from living vegetable organisms. While some alterations are made on these materials during manufacture and treatment, they never become physically inert and are thus subject to continual change, especially with the application of heat, and ultimate failure results in disintegration. The ones that readily oxidize, deteriorate most rapidly with heat. Some inorganic materials such as mica require the use of organic materials for their application and the final insulating value of the material depends upon the permanence of the organic materials used.

Before considering machine insulation problems and developments, it is well to review some of the more prominent insulating materials listed to determine of what and how they are made, their insulating limitations and field of applications.

Paper is widely used due to its cheapness and adaptability. It is manufactured from wood pulp, rags or plant fibre. Finished paper retains traces of the bleaching or coloring matter used in its manufacture. The mechanical properties are derived mostly from the basic fibres used and papers made from wood pulp are not as strong or tough as those made from linen or Manila fibres. Owing to its porosity it is hygroscopic and normally contains from 7 to 12 per cent of moisture. Paper shrinks on heating and becomes brittle, and at temperatures much above the boiling point of water carbonization begins. The dielectric strength, however, remains until practically completely carbonized. Extremely dry paper has a high dielectric strength, but it is difficult to keep paper dry. Average values of dielectric strength are from 100 to 225 volts per mil of thickness in thicknesses of 0.002 to 0.032 inch, depending upon the moisture content. Outside of low voltage insulation on wires, paper is used largely in insulation work to provide mechanical protection to other insulations, such as backings for mica, slot linings and core punching insulation. No special treatments are required for this purpose. If paper is heated or impregnated with oxidized linseed oil, a mixture such as oxidized oil and asphalt, or a gum base varnish, its insulation strength becomes in the neighborhood of 500 volts per mil.

Cotton, because it is strong mechanically and because it can be applied readily in the many forms in which it is supplied, finds wide application as an insulator. It is the seed hair of several plants of the mallow family. The fibre is hollow and when growing is a single straight cylindrical cell but on ripening the tube flattens and becomes contorted and twisted, making it possible to spin it. The number of twists in cotton fibre varies from 150 to 400 per inch. The diameter of the fibres vary from 0.0006 to 0.00085 inch. In spinning, a number of strands are given a slight draw and then twisted into a hard yarn. Certain agglutinants, softening materials and antiseptics are added during the spinning in order to bind the yarn together, absorb moisture, get close weaving and prevent mildew.

Cotton as an insulation of wire is easily applied with machinery by winding or spinning it around the wire as the yarn is being applied. Usually the insulation is applied in a single or double layer, (the latter having the layers wound in opposite directions for better results). Single cotton insulation on wires is approximately 0.0025 inch thick, while double cotton insulation varies in thickness from approximately 0.0045 inch to 0.01 inch, depending upon the size of wire. The ability of the yarn to wind or bind closely together as applied and to take up oils, gums or varnishes upon application or impregnation, gives this material a very large field of application. A seven mil two layer thickness has a puncture voltage of about 150 volts untreated and about 500 volts when impregnated. Cotton also finds a wide application when made into tapes and cloth, either untreated, treated or impregnated. Cotton tape

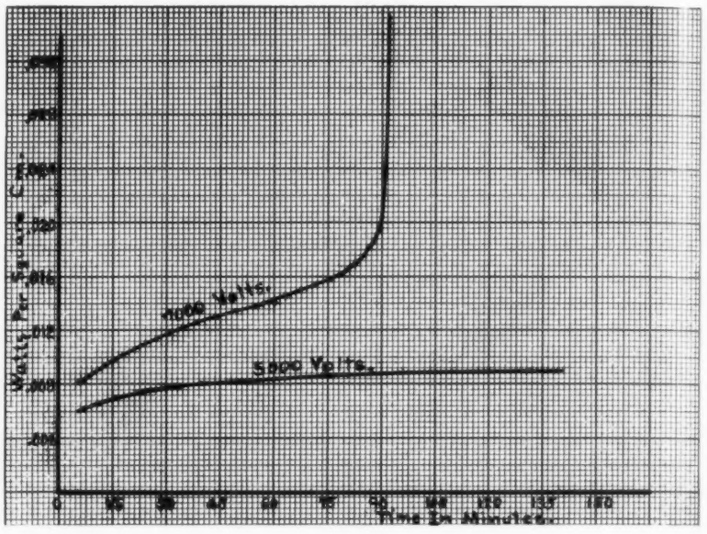


FIGURE 3—Curves showing the increase in dielectric loss with time for different voltages applied to varnished paper insulation.

has a very large field of application as it is mechanically strong and flexible.

Linen is a vegetable fibre obtained from the flax plant. The fibres come from small cells composed of practically pure unlignified cellulose and are 6 mils in average diameter. Linen is a better conductor of heat than cotton but contains about the same amount of moisture, is stronger than cotton and has about the same insulating qualities. It is not as cheap as cotton.

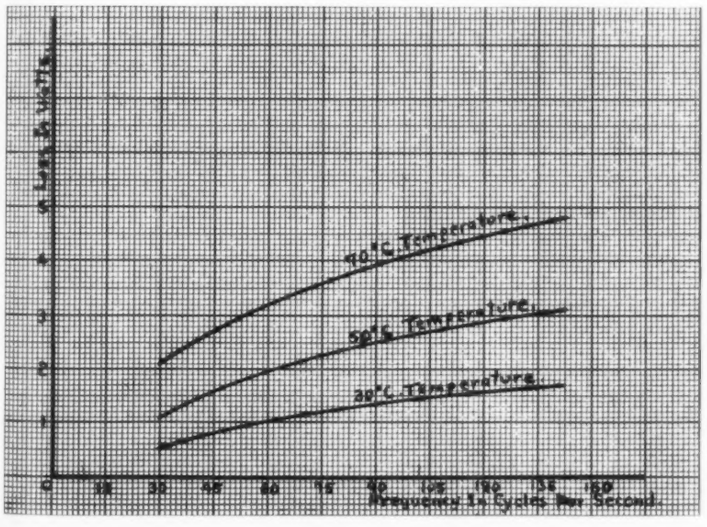
Silk is an animal fibre consisting of a continuous thread spun by the silkworm. This thread may be as long as a mile and varies in thickness from 0.0005 to 0.001 inch. The fibre is not cellular but in its natural state consists of two continuous homogeneous filaments of fibrin cemented together with a secretion called sericin. In manufacture this cement is often partially removed. Silk is an extremely hygroscopic material and may absorb 30 per cent of its weight of moisture and still appear dry. Silk has superior insulating properties to cotton and due to its fineness of texture it can be put on smaller diameters of wires than cotton. Due to its higher cost, its field of application is usually limited to the insulation of fine wires.

Pressboard denotes all materials sold as pressboard,

fullerboard and kindred products made by paper making processes from vegetable fibres but differs from papers in that it is made on a board machine and is afterwards subjected to heavy pressure, to remove excess moisture and to close up the fibres to secure a more solid material. This material, because of its relatively dense nature, has better insulation properties than paper. It has many applications of a mechanical insulation nature and as insulation spacers, and for provision for creeping surfaces.

Fibres in the form of vulcanized fibres have been used for many years in the electrical industry in relatively low voltage applications as spacing blocks, packing, joint insulation, fuse holder cartridges and slot wedges. This material is universally made of paper made from cotton rags. The paper layers are of a thickness of 5 to 7 mils and this paper is passed through a bath of a zinc chloride solution and wound on a large heated drum until the desired thickness of treated paper is built up. The resulting cylinder is slit parallel to the axis and the built up material is unrolled to form a flat sheet. It is then further treated chemically with weaker and weaker solutions and then washed for a long time, up to eight months, for the best quality 1 in. thick

FIGURE 4—Curves showing variation in loss with frequency of an applied constant electro-motive force in certain fibrous insulations.



fibre. It is then dried for many weeks at a 40 to 60 degree C. temperature. The insulating value of this material, which is roughly inversely proportional to its moisture absorption content, varies with the temperature at which it is tested and with its total thickness, being 25 to 200 volts per mil of thickness.

Laminated varnished paper and cloth products, in general, use the following three cements or bonds: (a) synthetic varnish bonds of the so called bakelite type, (b) material resins and gum bonds and (c) asphaltum bonds. Most all of these products are built up from specially selected paper which has been previously coated with the bonding cement material to be used. Previous coating of the paper is necessary in order to remove all traces of solvents in the bond before building up the laminated product. The bond is applied to the paper or cloth by passing it through a vat of the bond or by applying it by a roller kept wet with the bond. The drying must not overbake the bond but must drive off all solvents.

Layers of the treated paper or cloth are baked under high pressure up to as much as one ton per square inch at a sufficient temperature and time to change the bond into its final state.

While this material is not impervious to moisture, the amount absorbed by immersion is relatively small, from ½ to 3 per cent. Tensile strength is 8000 to 17,000 pounds per square inch. The dielectric strength varies from 100 to 400 volts per mil, depending upon the thickness and temperature. These synthetic varnish products have one serious short coming which is the inability to withstand subjection to an electric arc. Such a flash decomposes the product forming a carbonized path. The material has so many admirable characteristics that it finds a wide field of application in the electrical industry.

Shellac and other material resin and gum bond paper and cloth products have similar characteristics to bakelized material, except they may have a tendency to soften with continued application of heat. They have one important advantage, however, in that when subjected to an electric arc they do not so readily carbonize because during this period they liberate a considerable amount of gas and vapors, with sufficient explosive violence to throw out the decomposed products and to spread and dissipate the discharge.

Varnish products using ashphaltum bonds are very little used and have only restricted applications.

Asbestos is a fibrous mineral composed of silicates of magnesia and lime and may have ferrous impurities in the natural state which have to be removed when asbestos is used for insulating purposes. Material mined in Canada, Russia and South Africa has the best properties for electrical work. Asbestos may be made into paper by ordinary paper making machines but to give it an appreciable tensile strength, a small amount of cotton fibres is usually added. This small amount of class A structural material does not prohibit classifying the finished product as class B insulation. Asbestos fibres can be woven into yarns, cords, tapes and fabrics, using up to 15 or 20 per cent of cotton for structural purposes. As paper, tapes or fabric, it is used as insulation between bare copper conductors for turn insulation. Insulating tapes are usually 15 to 17 mils in thickness and thicknesses finer than about 10 mils are unusual due to the difficulty of spinning the asbestos fibres.

Although asbestos tapes have been used as an insulating covering for wire conductor in the form of thin asbestos tape lapped on to the conductor and held in position, and protected by a single cotton covering, a better and now almost universally used method consists of forming the asbestos directly around the wire and consists of applying the asbestos to the bare wire

in the form of pulp with some form of wax to improve its adhesion and prevent fraying.

From an insulating standpoint, asbestos has about the same qualities as cotton, although its fire resisting characteristics make it a class B insulator instead of class A.

Mica is the most important insulating material used in the electrical industry. It is a crystalin mineral consisting of 40 to 45 per cent silica, 25 to 40 per cent alumina, 10 to 12 per cent potash and various amounts of magnesia, ferric oxide and up to a small percentage of moisture. There are several different kinds of mica mined in various parts of the world but only two kinds, muscovite or potash mica called white or hard mica and phlogopite or magnesia mica called amber or soft mica, are used extensively in the electrical industry. Most of the former comes from India, while most of the latter comes from Canada.

Block mica of small slabs or plates of mica come directly from the mines but very little is used in the block form. Mica is formed of thin splitting from ½ to 2 mils in thickness and the mined mica is split usually by hand into the splitting, and graded and boxed, the splitting varying in size from approximately 1 in. square to pieces having an area of 24 to 36 square inches.

Built-up mica insulation is of two general classes: one in which the mica is built up on paper or fabric backing, and the other in which the mica is built up without any backing. In any case the built-up mica is made from flakes and may be made automatically or by hand. In the older automatic machines a measured amount of mica flakes was dumped in the top of the tower where the mica flakes fell by gravity and floated down in the tower landing on steel sheets which may or may not have had backing material on them, depending upon the type of mica to be built. Dry bond in the form of powder was dumped in the towers and went down through the towers with the mica mixed with it so that an average thickness of mica with bond interspaced was secured. The mica was then treated by pressing and heating in order to cause the bond to make the flakes firmly adhere to each other and build up a homogeneous mass of material.

Later types of machines use an endless chain or screen type belt on which the mica is built. This endless belt passes over a roller at each end. The first part of the belt for a distance of about 10 feet is exposed and is the building section. For a distance of about 60 feet the belt passes through a baking oven, after which the belt comes out from the oven and the mica is passed over sections that are water cooled in order to cool the mica. It is then trimmed and cut to fixed lengths forming sheets approximately 3 feet square. These machines also use towers and the mica falls by gravity through the towers passing by the end of the belt over one of the rollers which is perforated. There is located inside of the roller suction pipes that draw the mica flakes to the belt. The amount of mica deposited and held by the suction depends on the amount of mica dumped in the tower and the magnitude of the suction pressure. The more mica passing by the roller in a given time and the greater the suction, the thicker will be the built-up mica. Those mica flakes that pass by the roller and are not held by suction to the belt fall a short distance to the bottom of the tower onto an endless belt conveyor and are carried to the top where they again fall down the tower in the same process. The mica remains on the belt in a horizontal position and passes under a light continuous feed of wet bond, after which the mica is rolled by felt rollers and passes into the oven where it is baked and at the end of a given time, depending upon the speed of belt operation and the length of the oven, the mica will come out of the oven ready to be trimmed. Mica thicknesses from 0.005 in. to 1/16 in. can be built on machines of this type.

For building up thick sheets of mica as, for instance, for use in commutator bars and V-rings, better results can be secured from an insulating characteristic stand-

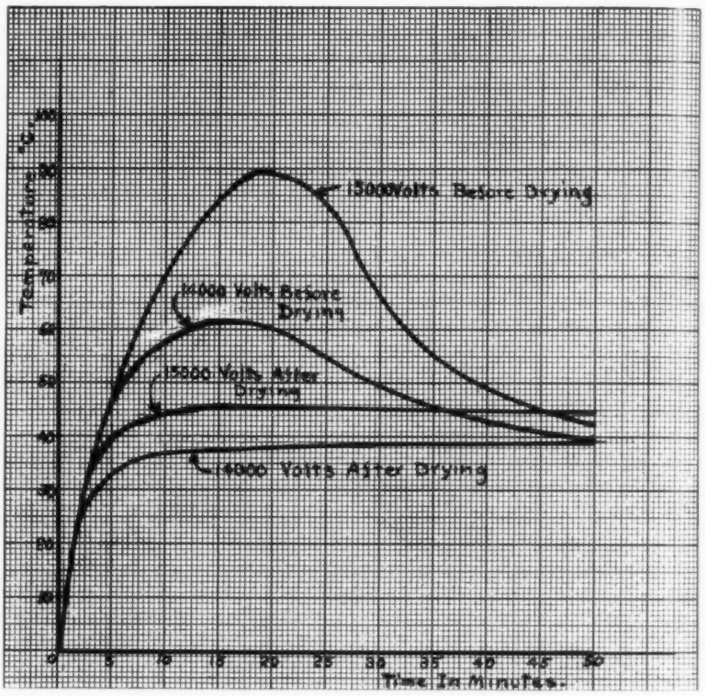


FIGURE 5—Curves showing temperature variation with time in a fibrous insulation under different voltages and moisture conditions.

point by using several sheets of relatively thin mica from 0.005 to 0.015 inch thick, turned 90 degrees in respect to each other and held together by bond, pressed and baked.

The best type of mica insulation, whether in wrapper or tape form, and the type that is used for insulating coils of rotating electrical machinery is built by hand. Paper backing with thicknesses of a few mils is passed over a long table. Girls sitting on each side of the table take the flakes of mica, piece by piece, and rapidly build up a mica covering over the backing. The mica flakes are usually one-half to one thousandth of an inch thick and the thickness of the mica as built up consists of a few thicknesses of overlapping flakes of mica. These operators become very expert and can lay the mica on overlapping so as to form a quite uniform thickness of

overlapped mica flakes. The individual thickness of flakes put on the backing by any operator is in the neighborhood of two or three. As the built up flakes pass on from the operators, they pass under felt rollers continuously saturated with bond and the bond is forced in between the built up layers of mica. When a mica thickness of 6 to 10 or more mils is required, several layers of overlapping flakes are put on by more than one group of girls located along the building table. As each few thicknesses of overlapping flakes of mica are built upon the continuous running strip, liquid binder is rolled into the space between the flakes by felt rollers saturated by binder. There may be as many as four rollers used on one sheet of thin built-up mica. By building the mica in several layers, each consisting of a few thicknesses of overlapping flakes, better distribution of the mica flakes on the built-up mica sheet is secured and a more even thickness and homogeneous structure is secured. The last operation consists of placing a 0.001 in. thick japan paper backing on top of the built-up mica by feeding it in on top of the mica after the last flakes are placed in position. This mica is not baked or pressed but some kinds are passed over heated rolls to drive out most of the solvent used in the bond. The mica is then rolled up on a mandrel.

Built-up mica wrapper is tested by passing it over a steel plate connected to one side of a high potential, the other side of the high potential being connected to a series of metal fingers riding on top of the mica. The test voltage is slightly less than the breakdown voltage corresponding to the thickness of mica being tested and any thin or weak spots are shown up by being punctured. Whenever a breakdown occurs, the machine automatically stops and an operator marks the punctured spot by punching a hole about $\frac{5}{8}$ in. in diameter through the sheet at the punctured point. The mica is again rolled onto another mandrel.

For use for armature coil insulation as wrappers, the continuous sheet of built-up mica is unrolled and cut into sheets of the required dimensions. Any sheet having a hole in it, indicating a punctured weak spot, is rejected and not used.

For mica tapes the built-up roll of mica is run through slitting machines and cut into approximately $\frac{5}{8}$ in. width and rewound in rolls of tape.

Built-up mica of this nature is not produced in large quantities and stored as it would dry out and lose much of its flexibility. It is, therefore, built approximately as needed. Even then that made into rolls of tape is placed in cans and sealed so as to keep it from drying out, as the narrow rolls of tape would dry out much faster than the wide rolls of wrapper.

Built-up mica can be fairly flexible or quite hard, depending upon the amount of bond used and the pressing process used.

White mica is universally used for electrical machine insulation and will stand working temperatures up to approximately 500 degrees C., while amber mica can be employed up to 1000 degrees C. The latter is, therefore, used exclusively in heating elements. Amber mica is also used as bar mica only on commutators that have flush mica, as it is softer than white mica and can thus be worn down by the abrasive action of the brushes running on the commutator.

In flake thickness of 0.002 to 0.003 inch the voltage required to puncture white mica is approximately 3000 to 4000 volts per mil, while amber mica has only about one-half this dielectric strength. Built-up mica used for coil insulation, of course, has less than these values, being about 300 volts per mil of thickness for average thicknesses of tape and wrapper. This is due to the laminated structure of built-up mica and the incorporation of a paper or fabric backing.

Glass is one of the oldest and one of the least used insulators until very recently. Glass in dimensions as ordinarily considered is a hard, brittle and commonly transparent amorphous substance made by fusing together silica as sand, an alkali as potash or soda, and some other base as lime or lead oxides. There are many different kinds of glasses of different constituents, depending upon the purpose for which made.

However, by drawing glass out into a very fine thread it becomes very flexible and finds many new uses as an insulator. It is the development of methods of making glass fibres in sufficient quantities so that they can be spun in threads and yarn, and woven into tapes, sleeving, cloth, etc., that has brought glass insulation into prominence recently and has opened a new field of insulation for electrical machinery.

Ordinary soda glass is slightly affected by moisture, so an alkali free glass was produced by the glass manufacturers in their development of this new glass product.

The fibres of glass as produced are from 0.0002 to 0.0003 inch in diameter and are made by remelting specially made glass marbles about $\frac{3}{4}$ inch in diameter at 2400 degrees F., and as the melted glass runs out of the bottom of the container through small holes, it is caught by jets of steam, drawn outward and pulled downward very rapidly onto a rotating drum.

One kind of glass fibres is called Stape fibre and is short in length and similar to cotton fibre in length, and is spun and woven similar to cotton. Continuous fibres are another kind and are produced in continuous lengths. Approximately 100 strands of extremely fine streams of glass are collected together and drawn into a revolving spindle. The continuous fibres are formed by the mechanical pull of this rapid spinning and are then combined by being twisted into any size yarn desired. The speed of drawing the finished filament controls the diameter of the glass fibres. One pound of glass will produce a strand of glass of 102 filaments, over 50 miles long. From the fineness of the filaments combined to produce the glass thread, it is easy to understand how a flexible glass thread, yarn, tape, sleeving or cloth can be produced. Although the glass marbles from which the finished product is made are transparent, the resultant thread is white in color due to its extreme fineness.

The characteristic that makes glass so valuable as an insulator is that it is 100 per cent inorganic and as such can be used at even higher temperatures than class B insulating materials. It is non-inflammable, has good tensile strength, higher insulation resistance than cotton, silk or asbestos, is non-hygroscopic, has higher thermal conductivity than most other insulations and resists moisture, acids, oils and corrosion. Its main defect is that it cracks or breaks when bent at too sharp radius or around too sharp a corner. Due to the silky

finish of the yarn, the fabric material has a tendency to slip when being applied.

As an insulator when used without impregnation, it falls in the classification of cotton, silk, or asbestos, in that it is a spacing material and its breakdown voltage is only slightly better than that of the air thickness it displaces. When impregnated, it has high insulation dielectric strength as does other fibrous materials when impregnated, with one advantage that it will not absorb moisture.

When it can be used as a space insulator without impregnation, at low voltages between conductors, such as on coils or lifting magnets, it has no competitor because it can stand much higher temperatures and is mechanically much stronger than any competing insulation. It can actually operate above 650 degrees C. before it takes a permanent set.

At present practically all sizes of round wire are being made with glass insulation and the insulation in the form of tape, braided sleeving, and woven cloth is available. In combination with mica, glass may be a substitute for paper and cloth fabrics, thus raising the temperature limitations on built-up mica wrappers and tapes.

FIGURE 6—Field coils are wound under tension, insulating compound being applied as the coil is rotated.

Oxides are sometimes used as insulators, the most familiar application being the oxides on punchings which act as an insulator to reduce eddy current flow. Another application sometimes used is the oxide of aluminum used on aluminum wire, which has sufficient insulation characteristics for conductor insulation on such applications as low voltage shunt field coils.

Another group of materials has a prominent position in connection with built-up insulation used in electrical machinery manufacture. These are compounds, shellacs, varnishes and enamels. Their chief purpose is to act as fillers in the pores or interstices, taking the place of air in these voids and forming a compact structure. Since resulting temperatures of operation are not only due to the heat loss but the ability to get rid of the heat, these materials lower the operating temperatures by eliminating the heat insulation produced by the air pockets in the pores of insulation and between layers and turns. At the same time, due to their relatively high dielectric strength, their permeation throughout the insulating material, especially in fabrics, increases many fold the breakdown voltage. Developments in these materials during the past 10 and 20 years in producing better penetration, better filling of voids, more flexible materials in some cases, stiffer materials in others, characteristics in not running out, better insulating qualities, have been of major importance in improving the quality of insulation and permitting reductions in the space required for insulation, with accompanying greater output per pound of material.

Enamel covering for wire has been used quite extensively for many years, especially in the smaller sizes. In the larger sizes enamelled wire often has a single cotton covering applied which acts as a mechanical protection to the enamel and as an additional insulating spacer. Enamelled wire is made by passing the wire through vats containing the enamel, after which it passes over pulleys or rollers in heated towers in which the enamel is baked at a relatively high temperature, only slightly below the annealing temperature of copper. This causes considerable trouble in the smaller sizes of wire, due to stretching. The enamel used is generally a china wood oil base varnish blended with special resin. Improvements that have been made in enamelled wire have been in the compounding of the enamel, making a more flexible enamel. Enamel wire is tested by passing it through a bath of mercury. Pin holes or other defects are indicated by the passage of an electric current from the copper to the mercury.

Enamelled wire is used almost exclusively in small coils and transformers, and even in armatures and field coils of small rotating electrical machines.

Let us now consider the actual improvements that have been made in rotating machine conductor and coil insulation.

Field coils, because they have lower voltage applied to them and because they have the easiest insulating problems, will be considered first.

The field coils of d-c. machines in the early days

when machines were large, heavy and inefficient, were large in cross section and high internal temperatures resulted, especially in reference to the surface temperature. Some of these coils even had a layer of cotton twine or cord wrapped over the outside layer of wire to give a better appearance, a construction which indicated lower temperatures as measured by thermometer and conversely tended to hold the heat in the coil. Usually round cotton covered copper wire was used. Practically no treatment but a finished varnish was used.

When the fallacy of this construction was realized, the coil was divided in pancake layers, the plane being perpendicular to the radial axis of the pole. This was an improvement in that cooling air could get in the ventilating spaces between the pancake layers.

The next development consisted of making thin coils concentric with the pole with single, double, or even sometimes triple concentric sections. Better cooling was secured as the vent ducts were radial and air discharged from the rotor easily passed through them, effectively cooling the coils. In the larger sizes, square wire was used as it gave a better space factor and reduced air pockets, giving better heat transfer. These coils were gum impregnated by the vacuum pressure method of placing the coils in a container, evacuating it, and then submerging them in heated gum compound under pressure.

All these coils had the ground insulation incorporated in the coil using layers of insulation bound to the coil to give creepage and ground insulation.

Modern shunt field coils are similar in construction to the concentric thin coils, except they are wound directly on the insulated poles instead of on a former. Fullerboard insulating channels with treated laminated wood end shields are used for ground insulation around the pole body for class A coils and formed mica channels and compound end shields when class B insulation is used.

The poles are mounted on a winding head and rotated, and the wire wound directly on the insulated poles, under tension. Figure 6 shows such a coil being wound. Insulating compound is applied as the coil is being wound, thus assuring all parts of the coil being treated by the compound which was not always accomplished by the vacuum pressure method.

For class A coils, enamelled insulated wire for the smallest sizes, and cotton and paper insulated wire for the medium and largest sizes are used. Newer developments in paper insulation and in methods of applying it have made this type of insulation a good competitor of cotton insulation. It has better insulation qualities and as good mechanical strength, and does not have the tendency to slip along the wire. This insulation will find a wider application in the future.

For class B coils, asbestos in various forms has had the field to itself until the advent of glass insulation. Asbestos is mechanically weak and the manufacturers did not like it for that particular reason, although it was used.

For a-c. rotating machines the field coils which are usually rotating are wound with double cotton insulated wire for class A.

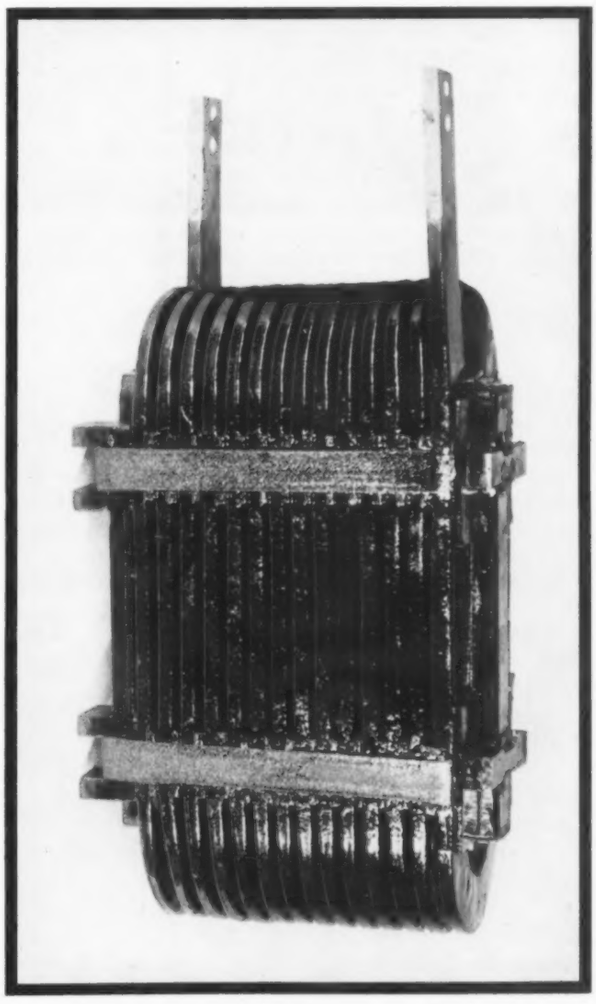
The medium and smaller size machines use a construction similar to that of d-c. machines, except that the coils must be wound to take the centrifugal stresses of rotation. Ventilated type of coils have not been used in general for mechanical reasons.

On larger size units, particularly on long core machines, the coils are mould wound, using insulated wire with the completed coil fully insulated from ground before assembly on the pole. For class A insulation, tailor made cells of treated cloth and fish paper are used and for class B, flexible mica bound with asbestos is used. Mica with a glass backing will probably find an application here.

The treatments of the wire wound coils are similar to those given to d-c. shunt field coils, except that an operation of hot pressing is applied to most of the coils to form them into a bricklike mass to withstand the centrifugal forces they encounter.

The largest size coils are made of heavy bare copper

FIGURE 7—Commutating field coil of modern design, made of a bare copper strap wound on edge.



strap wound on edge. The insulation between turns consists of layers of treated asbestos paper or asbestos paper and mica. The same type of ground insulation is used as for wire wound coils. These coils have bare edges for heat dissipation and many of them have some of the turns extended bare on the ends to give more surface for still better heat dissipation.

Three types of commutating coils are used on d-c. machines. On small commutating pole machines insulated wire coils built similar to shunt field coils are used. Bare strap coils are used on larger units and are either of the ventilated type with fibre or fullerboard spacers between turns, or of the solid type with asbestos spacing approximately ten mils thick between turns. In any case suitable insulating channels are used around the pole for insulation between the coil and the pole. For higher operating temperatures, glass insulation could be used between turns and moulded mica and glass insulating channels could be used for pole insulation. Figure 7 shows a commutating field coil made of bare copper strap wound on edge.

Armature coil insulation for both d-c. and a-c. machines has undergone tremendous improvements in the past 25 years. This development has all been toward one end, better insulation with less space required for it, so that more copper can be used, giving a greater output for a given size machine. In general, this has been brought about by using thinner but higher quality insulation. Treated cloth insulation such as empire cloth was considered very good insulation on quite old machines, while later mica insulation was used in the slot part and treated cloth on the end portions of the coils. The modern trend is toward full length mica insulation, particularly on coils the ends of which rest against some sort of metal support.

Our company has pioneered the use of mica insulation on armature coils and as early as 1897 used an interwoven rope paper and mica wrapper for insulation on the slot portion of d-c. armature coils. A woven-in wrapper insulation is indicated in Figure 8 which shows a cross section of an armature coil with four conductors. It will be noticed that the insulation between conductors is a portion of the same wrapper that, after being interwoven between the conductors, forms the coil insulation to ground. The number of turns of wrapper around the group of conductors was usually $1\frac{1}{2}$, $2\frac{1}{2}$ or $3\frac{1}{2}$, depending upon the voltage of the machine, its size and class of service. The disadvantage of the woven-in wrapper is the chance of its slipping, with a possibility of shorts between conductors and the inability of getting the wrapper tight on the coil.

Modern d-c. machines have the conductors insulated with mica tape throughout the full length of the conductors, that is, on both the slot or straight sections and on the ends. The coil insulation consists of mica wrapper on the slot portions and mica tape on the end portions. Obviously, mica wrapper cannot be used on the ends due to curves and bends. For class A coils, cotton tape is usually used as a binder and either asbestos or glass tape on class B coils.

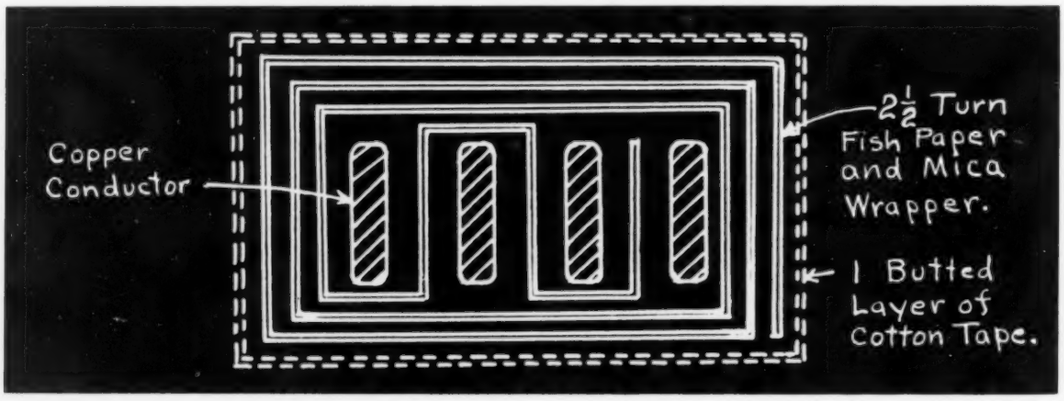


FIGURE 8—Cross-section of a d-c. armature coil with four conductors, showing a woven mica wrapper.

The insulation on most modern medium and large size armature coils is solidified on the straight portion by treating with synthetic resin bond under temperature and pressure, giving a solid fairly rigid and to-size coil, particularly in the slot portion. The ends will be more flexible to permit winding without damage. Some of the smaller size coils for class A machines receive no treatment until after winding and for a low voltage small size unit, enamelled cotton covered wire with only a slot cell provides sufficient insulation.

Figure 9 shows a coil for a large size d-c. motor using mica insulation on the conductors and on the coil for ground insulation, and a woven glass tape as an outside binder. Figure 10 shows the armature of a 5000 hp., 700 volt, 40/80 rpm. reversing steel mill motor being wound with these coils with glass insulation on them. They are wound and treated exactly the same as coils with cotton or asbestos tape on them. Figure 11 shows two of these 5000 hp. motors, with glass insulated coils, coupled together on our test floor last summer for overload runs. These are the largest and only reversing

mill motors in operation to date, using glass insulation on the armature coils.

The armature coil insulation of induction and synchronous motors is, in general, similar to the insulation on d-c. machines, except, of course, more turns of insulation are used on the coil-to-ground insulation on the higher voltage machines, as many as 16 turns or thicknesses of mica insulation being used on machines having voltages in the neighborhood of 15,000. Also, since the voltage per turn of large size a-c. generators may be as high as 300 volts, conductor insulation must be heavier than in d-c. generators, where the voltage per turn very seldom exceeds 10 or 15 per cent of this value.

On class A coils, treated cloth tape such as empire tape is generally used on the end windings. Approximately the same number of turns or layers of this cloth is used as the number of turns or layers of mica insulation on the slot portion of the coil.

On class B coils, the conductor or strand insulation has generally been asbestos or mica tape throughout the entire length of the coil. Asbestos insulation is generally used on transposed conductor coils.

Mica folium insulation was one of the best types of insulations developed. It consists of an extremely high grade mica wrapper, wrapped about the insulated conductors on the slot portions of large size a-c. generator coils. The wrapper was heated, pressed and tightened around the coil by being "ironed" around the coil by heated iron shoes which were revolved around the coil insulation. The heat softened the mica, the pressure held the insulation close together and the revolving of the shoes wound the insulation tighter and tighter around the coil. The one disadvantage was that the insulation was so tightly bound around the coil that it made too stiff a coil for convenient winding.

Present coil insulation uses multi-layers of mica wrapper and mica tape on the straight and end portions of the coil, with suitable impregnation supplied during the building.

On higher voltage a-c. machines, corona is produced which will eventually lead to coil failure. We overcome this by applying a conducting compound over the slot portion of the coil to get the desired resistance and the resistance on the end turns is graduated to reduce the voltage stress to a negligible value.

It is always interesting to look forward as to what might be expected in the future. Based upon present materials, including the newly developed glass insulation, no phenomenally new developments of insulation can be expected under the present standards to which electrical machinery is built.

Mica due to inherent heat resisting qualities and its especially good dielectric properties will not be displaced by any of the present insulating materials, in its wide use as ground insulation on rotating electric machinery. Building up mica in flake form is not a disadvantage, in fact, this is what gives to mica insulation flexibility and thus permits its widespread use. The use of class A materials in structural form in built-up mica is its present drawback. Substitution of thin glass backing on which mica flakes can be built up will extend built-up mica to higher temperature classifications.

The next important step in reducing the size and cost of rotating electrical machinery will be operation at higher temperatures and glass insulation is going to have a big part in this. For strand and conductor insulation, glass can be used in place of cotton and paper for present low temperature insulations and in place of asbestos and built-up mica for higher temperature insulations. It is ideal in this instance in that it will be located in the hottest spot, that is, next to the copper conductors; it will be between conductors themselves where there is but little voltage difference and stress and it can be easily applied to the conductors. For the coil insulation, which is the insulation to ground, built-up mica on a thin glass fabric backing will be used, although on smaller and perhaps medium size units of relatively low voltage, glass insulation alone could be employed. For a binder to hold the coil to ground insulation in place, glass tape will be used.

For field coils glass insulation for high temperature operation can be used and undoubtedly will meet all requirements.

However, the problem of obtaining smaller, lighter and cheaper machines is not as simple as using higher temperature insulations and working the machines

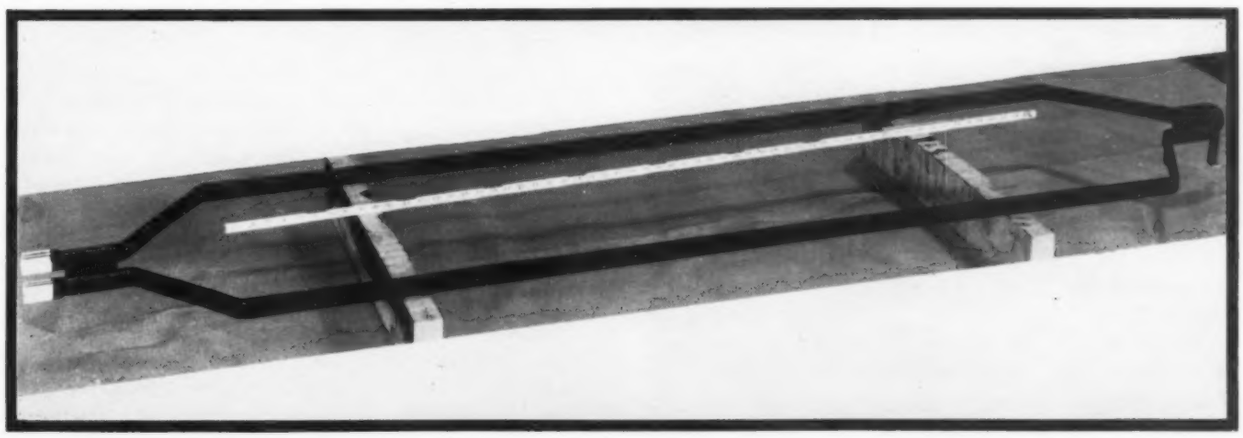


FIGURE 9—Coil for large d-c. motor, employing mica for ground insulation and glass tape as an outside binder.

FIGURE 10—Armature for 5000 hp. reversing mill motor, in which mica insulation is used with glass tape as an outside binder.

harder. There are many other characteristics and operating limits of machines besides temperatures.

In d-c. machines, particularly in the larger sizes, commutation especially on overloads is a limiting feature. Rating machines higher with accompanying higher temperature rises will be to the detriment of commutation. Saturation of the commutating pole generally limits commutation at increased loads. What then is needed is a steel for the commutating pole that has appreciably higher flux capacity, but unfortunately such material is not available. For d-c. machines that do not have to carry any appreciable overloads, which are usually few in number, such limitations would not exist.

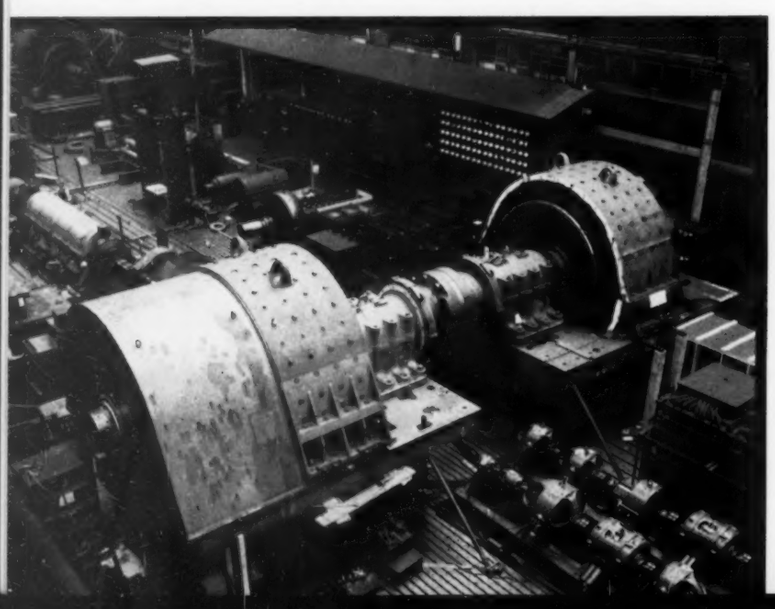
Operating performance, such as speed regulation in d-c. motors and voltage regulation in d-c. generators, falls off rapidly with overloads, which is another drawback to high temperature operation.

There are also other limitations imposed by temperature on other parts than conductor insulation. Commutators cannot be operated at too high temperatures or they will develop bar to bar roughness giving poor commutation. Higher temperatures will give problems of expansions, most all of which can probably be solved.

In a-c. machines there are similar problems. In motors, starting torques will be proportionally reduced as the motors are rated higher, poorer power factors will result and expansion problems will also be met. In large size a-c. generators some problems of expansions at high temperature operation, such as chaffing of armature coil insulation due to the difference in expansion of copper and core iron, in long core machines, are almost impossible of solving except by moderate temperatures of operation.

This is the present status of this situation but continued improvements and developments will lead to solutions of these problems in a most satisfactory manner and we will see reduction in frame sizes, lighter machines and improved performance in electrical machinery through improved insulations and higher operating temperatures.

FIGURE 11—Test floor view of large d-c. reversing mill motors using glass insulation on the armature coils.



DISCUSSION

PRESENTED BY

F. O. SCHNURE, Electrical Superintendent, Bethlehem Steel Company, Sparrows Point, Maryland.

L. H. FISTER, Foreman, Power and Transmission, Bethlehem Steel Company, Bethlehem, Pennsylvania.

R. H. TURNER, Day and Zimmerman, Inc., Philadelphia, Pennsylvania.

G. O. VAN ARTSDALEN. Maintenance Superintendent, Henry Disston and Sons, Philadelphia, Pennsylvania.

L. F. COFFIN, Superintendent, Mechanical Department, Bethlehem Steel Company, Sparrows Point, Maryland.

H. J. STEWART, Engineer, Wire and Cable Department, General Electric Company, York, Pennsylvania.

LOUIS NICHOLS, Foreman, Armature Winders, Bethlehem Steel Company, Sparrows Point, Maryland.

RANDALL HAGNER, Owens-Corning Fiberglas Corporation, Toledo, Ohio.

D. M. PETTY, Superintendent of Service, Bethlehem Steel Company, Bethlehem, Pennsylvania.

C. LYNN, Manager, Direct Current Generator Engineering Department, Westinghouse Electric and Manufacturing Company, East Pittsburgh, Pennsylvania.

F. O. SCHNURE: Mr. Lynn's instructive talk has answered most of my questions and I might add, destroyed a hope that insulation research physicists and chemists were on a fair way to develop some kind of

impregnation for cotton that would increase its useful life. It is discouraging to see motors in service with insulation flaking off field coils or from stator and armature coils and to realize, but for the lack of a proper preservative, they are soon due for a re-winding.

The aging of cotton and varnished cambric insulation on spare coils is also a problem and is one which we have attempted to solve either by having the most important units wrapped in cellophane; or by retaining them in the original packing boxes, rendered fireproof by a sheet metal covering or by storing them in air tight enclosures.

L. H. FISTER: I am particularly interested in the effect of insulation upon the heat-flow or dissipation of heat in the parts of electrical machinery. My own observations have been that the effect of heat has been more harmful to the mechanical properties than it has been to the electrical properties. Most fibrous insulations, particularly the cellulose type, when they are exposed to a high temperature for a long period of time or exceedingly high temperature for a much shorter period, show a tendency toward becoming very brittle and in time may carbonize to a greater or less extent. However, for moderate voltages, such as encountered in the ordinary steel mill, this brittle, semi-carbonized condition does not seem to greatly affect the insulating qualities. The real harm seems to lie in the deterioration or possible injury to the mechanical properties in that the material may become so brittle that it will not withstand mechanical shocks and vibrations, and it may crack or even scale off so that the insulating quality will be seriously impaired simply due to mechanical defects.

I should like to know what treatment or series of treatments Mr. Lynn would recommend applying to windings on machines in the field to reduce this condition to a minimum and extend the useful life of the insulation. I also would like to know whether the equivalent of some sort of heat-life test has been made to determine the effect heat has on the mechanical and electrical properties of this new glass fibre insulation.

R. H. TURNER: I would like to know to what extent this new glass insulation has been applied to small electrical apparatus such as contact coils, small motor windings, magnets and solenoids. I would like to know how much commercial use has been made of it up to date.

G. O. VAN ARTSDALEN: I would like to know which is the most satisfactory impregnation on the new insulation.

L. F. COFFIN: I would like to ask Mr. Lynn how much more effective the newer types of glass insulation are in resisting various forms of atmospheric fumes and gases and especially oil vapors.

H. J. STEWART: There is one question I would like to ask in reference to the differential in heat stability indicated between glass and other Class B insulations. How much consideration is being given to the impregnating varnish? It seems to me that unless there is considerably more development work undertaken to raise the temperature limits and heat stability of the impregnating varnishes, we are not gaining very much.

L. NICHOLS: I have enjoyed Mr. Lynn's paper very much, especially with regard to glass insulation and I don't think I can add very much excepting to say that we have run several tests on glass insulation and several tests on coils that have been brought to us by different manufacturers. For instance, we took a coil from a certain manufacturer and a coil from stock and placed them in a tub of water for a period of ten hours. The following day when we made a test on these coils, we found that the old stock coil with ABA insulation held up much better than the glass insulated coil. I think the stock coil broke down at 2500 volts, while the glass insulated job broke down at approximately 1100 volts. So, while Mr. Lynn's paper gives considerable discussion to the effect produced by heat on glass insulation, it makes me wonder how this type of insulating material will be effected by moisture.

RANDALL HAGNER: The first point I do want to bring out is that people are expecting too much of glass insulation from a temperature standpoint. I have even heard an engineer say "Oh, I will not think much of it until it will withstand the temperature of copper. When it does, come around and talk to me". The whole idea of the temperature glass insulation will stand has been overemphasized and is very much misunderstood. The yarn itself will safely stand well over 1,000 degrees F. but it is so that the temperature is very much limited by the impregnants used. At the same time all leading synthetic resin manufacturers are now making higher and higher temperature synthetic resins to be used as impregnants, so it is so that the material, even impregnated, will stand very high temperatures.

We well realize that motors, generators, transformers and other types of electrical equipment have their NEMA temperature limitations, efficiencies, power factors, starting torque, and many other limitations, so this matter of glass insulation temperatures has no doubt been overdone, and has not helped its development and use by manufacturers.

Glass insulation is not perfect and certainly has its many imitations. It has many good electrical properties: it is of unusual strength; it is non-hygroscopic; withstands high temperatures; has high thermal conductivity; and the yarns, tapes, and cloths can be made so fine and thin that the space factor is most important and of great interest to designing engineers. It is made into tapes which are being used in place of cotton and asbestos tapes; a cloth starting with a 2 mil thickness is being used in place of cotton and asbestos in laminated compound products; a cloth is now being varnished to be used in place of varnished cambric in cables and such equipment. Braided sleevings are manufactured to be used on coil terminals and the like, and manufacturers are now producing varnished impregnated and saturated braided sleevings. The yarns, roving, and sliver yarns are used by wire and cable manufacturers in the place of cotton, asbestos, silk, rayon, and paper as an electrical insulating material.

Glass insulation is going into practically every electrical field as before mentioned. Leading manufacturers are actually in production on glass insulated class C motors and generators; transformers of all

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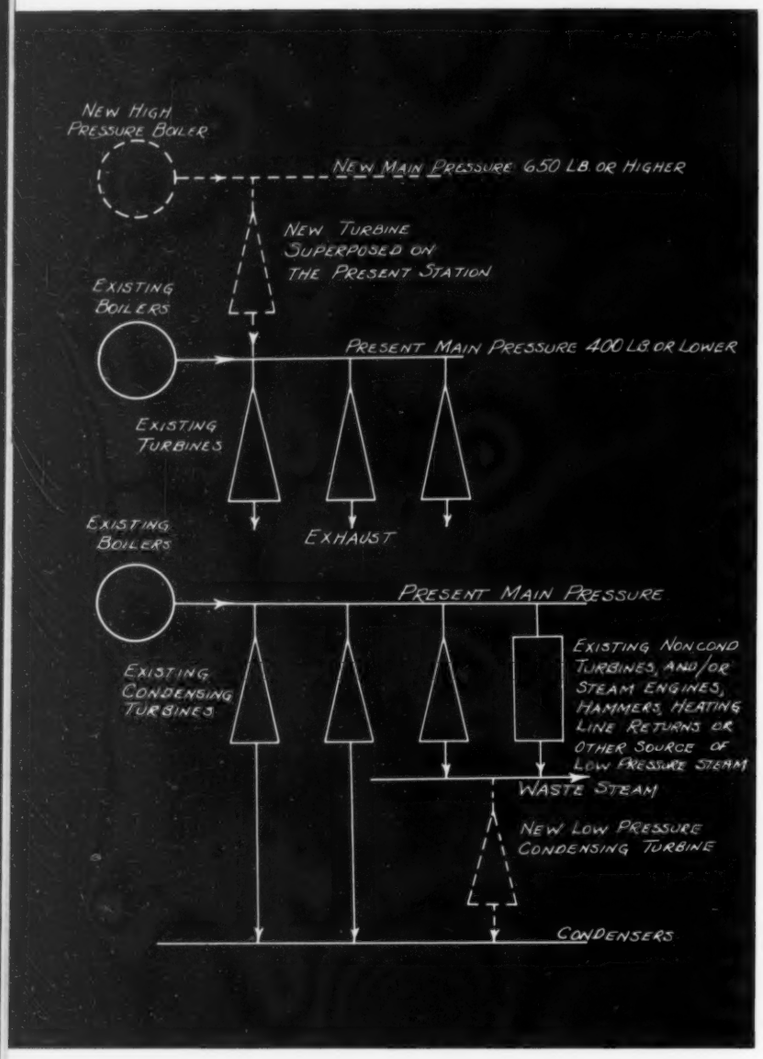

NEW HIGH PRESSURE BOILER
NEW MAIN PRESSURE 650 LB. OR HIGHER
NEW TURBINE SUPERPOSED ON THE PRESENT STATION
EXISTING BOILERS
PRESENT MAIN PRESSURE 400 LB. OR LOWER
EXISTING TURBINES
EXISTING BOILERS
EXHAUST
PRESENT MAIN PRESSURE
EXISTING CONDENSING TURBINES
EXISTING NON-COND TURBINES, AND/OR STEAM ENGINES, HAMMERS, HEATING LINE RETURNS OR OTHER SOURCE OF LOW PRESSURE STEAM
WASTE STEAM
NEW LOW PRESSURE CONDENSING TURBINE
CONDENSERS

FIGURE 1—Graphical presentation of superposed and low pressure condensing turbines to existing installations.

SUPERPOSED a
TURBINES fo

By L. E. NEWMAN

Turbine Division

GENERAL ELECTRIC COMPANY

SCHENECTADY, NEW YORK

▲ OBTAINING additional power for the same total fuel cost from an existing steam power plant is often easily accomplished. Superposition of a high pressure "topping" turbine will enable an existing power plant to generate 25 to 50 per cent more power from the same total quantity of fuel burned—and, when waste steam is available at about atmospheric pressure, low pressure condensing turbines will generate additional power at no increase in fuel cost. Either of these two types of steam turbines, properly applied, will pay for itself within a relatively short time.

Because of the position superposed and low pressure condensing turbines occupy in the steam cycle they may be called "tops" and "bottoms". Many steel mill power plants offer opportunities for savings with tops and bottoms—savings that go, dollar by dollar, directly into net profit. When you consider that the usual condensing turbine, operating with a main pressure of 200 to 400 lb., will require a yearly expenditure for steam supplied it equal to its purchase price, savings in the power house loom large as a potential source of increased profit.

In this discussion we shall limit ourselves to a few charts from which you can easily estimate the possibilities for savings from superposed or low pressure condensing turbines in your power plant. We shall set up briefly some of the factors which must be taken into account when applying either of these two types of steam turbines. And along with the advantages of these turbines we shall call attention to some of the disadvantages. By these steps it is hoped that those interested in their power plants as a potential source of increased profits will be able to make studies leading to worthwhile savings.

Looking first at the possible application of a superposed turbine here are the conditions favorable to its installation:

1—Additional power generating capacity is needed.
2—The present station main pressure is 400 lb. or less.
3—Supply of cooling water for condensers is limited.
4—Existing boilers are old and must be replaced.
5—Fuel is costly.
6—Governors of present turbines are unable to hold frequency as closely as is desired.

Oftentimes one of these factors alone is sufficient to justify the installation of a superposed turbine as the first step in modernization of a power plant. But

and Low Pressure for Steel Mills

Presented before A. I. & S. E. Birmingham
District Section, November 28, 1938

against these should be set the following factors unfavorable to the installation of a topping turbine:

1—Adequate generating capacity.

2—Station main pressure above 400 lb.

3—Cheap fuel with adequate supply of condenser cooling water.

Because a station now has adequate power generating capacity is not in itself a bar to considering the installation of a superposed turbine. For example, fuel may be sufficiently costly to justify the purchase of a superposed turbine from the standpoint of fuel saving alone, even though the station has ample generating capacity. Taken by and large, superposition pays its biggest dividends when the existing main pressure is low and fuel is expensive. But it should be remembered that a superposed turbine generates additional power at no increase in steam flow to condensers, and oftentimes is the only means of adding steam generating capacity when condenser cooling water facilities are the limiting factor.

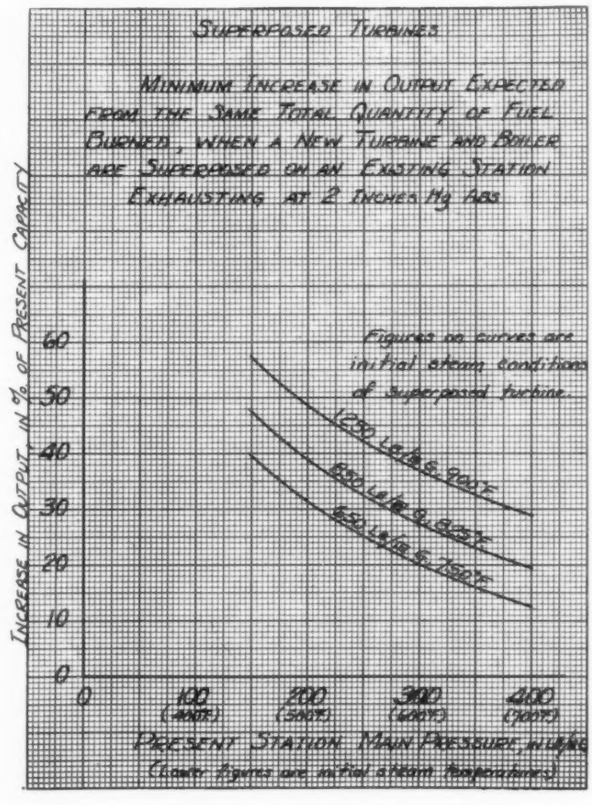
How much increase in capacity is possible from the same fuel consumption can be quickly estimated from Figure 2. For example a station with 20,000 kw. of condensing turbines operating with an initial steam pressure of 300 lb. could increase its capacity at least 37 per cent or 7400 kw. by installing a 1250 lb. superposed turbine. Figure 2 is an approximation which makes it easy to estimate the possible increase in output for the same fuel consumption when new turbines are superposed on existing condensing turbines. It is based on condensing turbines exhausting at 2 in. Hg. abs. (28 in. vacuum). With poorer vacuum the gains will

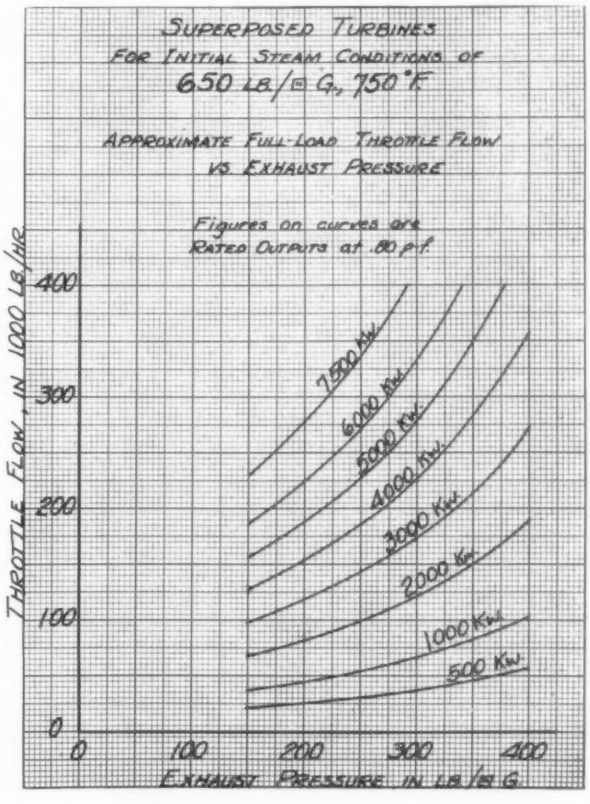
Below

FIGURE 2—Chart for estimating possible increases in output for same fuel consumption with superposed turbine.

Right

FIGURE 3—Chart for determination of power production for various flows of 650 lb., 750 degree F. steam.


Superposed Turbines
Minimum Increase in Output Expected from the Same Total Quantity of Fuel Burned, when a New Turbine and Boiler are Superposed on an Existing Station Exhausting at 2 Inches Hg Abs.
Figures on curves are initial steam conditions of superposed turbine.
1250 Lbs & 900°F
650 Lbs & 825°F
650 Lbs & 750°F
Increase in Output in % of Present Capacity
0
10
20
30
40
50
60
100 (400°F)
200 (500°F)
300 (600°F)
400 (700°F)
Present Station Main Pressure in Lbs
(Lower figures are initial steam temperatures)



be slightly greater, and conversely, with better vacuum the gains will not be as great.

Gains in output read from Figure 2 are theoretical gains based on the assumption that no steam is taken from the exhaust of the superposed turbine (cross-over line to the condensing turbine) and moreover that the new turbine is no more efficient than the existing turbine. As such, the gains in output are minimums. Actually from 10 to 25 per cent greater capacity may often be installed when these two factors are taken into account. One further point is that increased output is obtained from the same fuel consumption. If new high pressure boilers replace old lower pressure boilers the new boilers will usually be more efficient than the old boilers. Perhaps enough to more than offset the higher fuel consumption required to produce steam at the increased pressure and temperature. So, many times, the superposed turbine adds capacity without increasing the total fuel cost—always it will lower the unit fuel cost of power.

A more exact measure of the capacity which can be added by superposition is shown in Figures 3, 4 and 5. Here it is only necessary to enter one of the charts at the present station main pressure (exhaust pressure of superposed turbines neglecting drop), and read the output which may be obtained from a given steam flow through a superposed turbine. Thus, a station having use for 200,000 lb. of steam at 300 lb. pressure could obtain this from an 850 lb. 5000 kw. superposed turbine. (Figure 4.)

The field of application for low pressure condensing turbines is more limited than the field for superposed turbines, but given favorable conditions no other prime mover regardless of type will pay for its installation more quickly. The conditions favorable to the installation of a low pressure condensing turbine are:

1—A fairly constant flow of waste steam at atmospheric or higher pressure is available.
2—Ample cooling water for the condenser is available.
3—Additional generating capacity is needed.
4—Boiler feed water must be conserved.
5—Fuel is costly.

Unlike the similar list of favorable conditions for superposed turbines, a low pressure condensing turbine must have at least the first two favorable conditions present in order to justify its installation. The necessity for conserving boiler feed water and high fuel cost are added reasons for installing low pressure condensing turbines; but unless waste steam is available for power and ample cooling water for the condenser can be obtained, do not consider the installation of such a turbine. But these two factors in themselves are sufficient to make a low pressure turbine pay for itself in an amazingly short time.

Against these favorable conditions should be set the unfavorable conditions.

FIGURE 4—Chart for determination of power output for various flows of 850 lb., 825 degree F. steam.

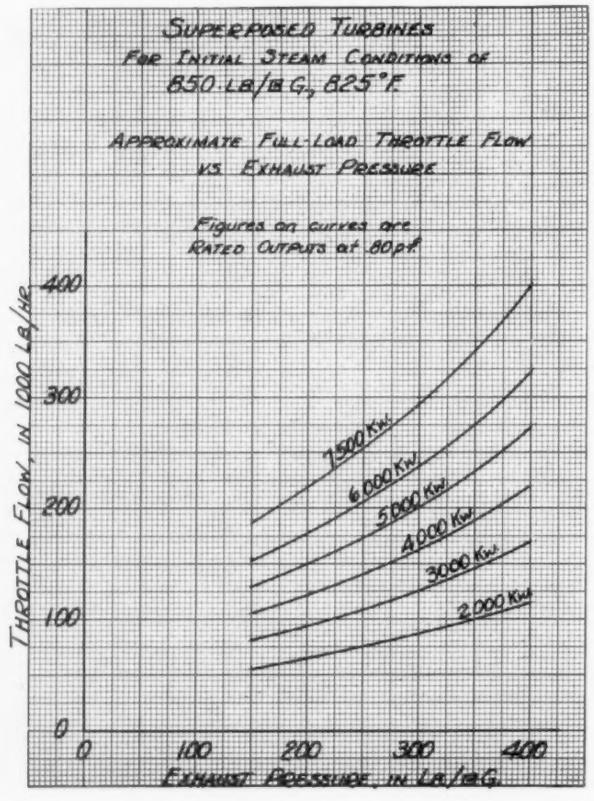
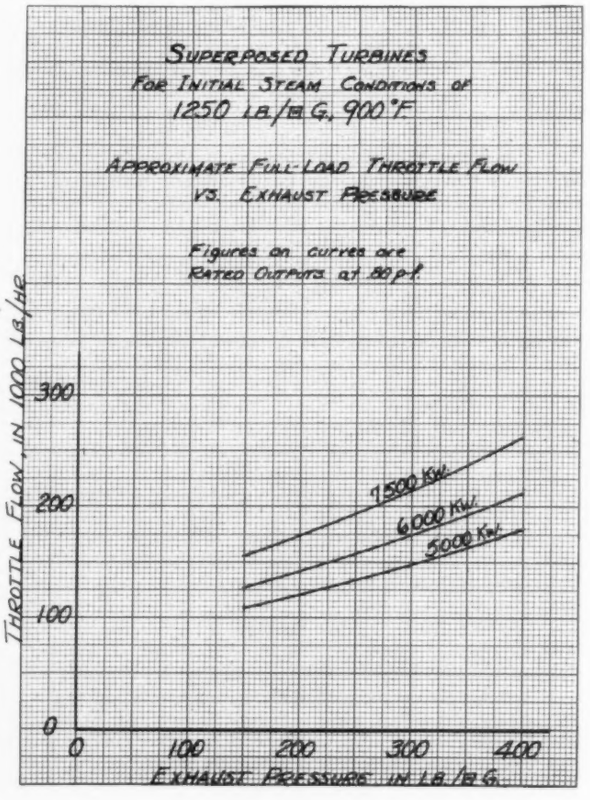


FIGURE 5—Chart for determination of power output for various flows of 1250 lb., 900 degree F. steam.



1—Low pressure steam is not being wasted, or is intermittent in flow.

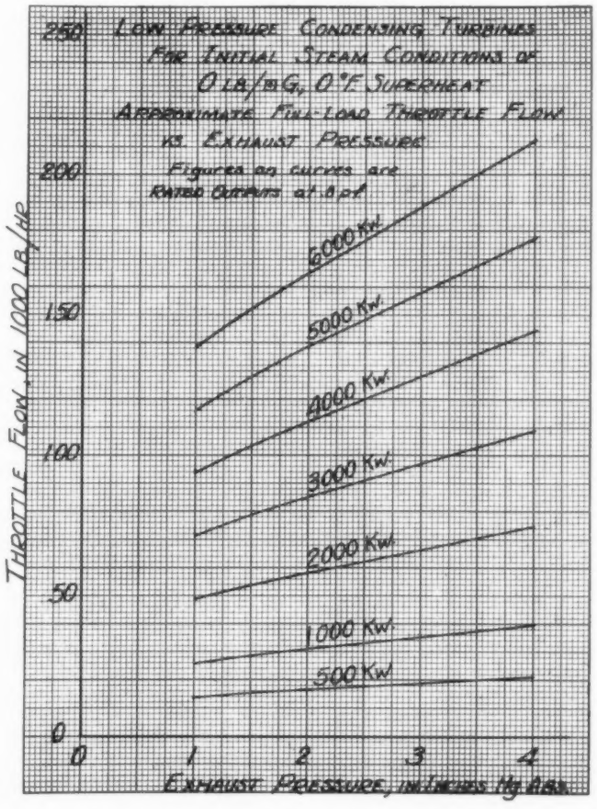
2—There is limited cooling water for the condenser.

3—Additional generating capacity is not needed.

Steam for low pressure condensing turbines is steam ordinarily thrown away. It may come from non-condensing turbines, or engines, steam hammers, heating line returns, or a similar source. If fairly constant in flow it may go directly to a low pressure turbine, if intermittent a steam accumulator can be installed to smooth out the larger fluctuations. How much capacity can be installed for a given steam flow is easily estimated from Figure 6. For example should there be a source of waste steam discarding an average of 35,000 lb. of steam an hour at about atmospheric pressure, reference to the chart will indicate that a turbine could be installed exhausting at say 3 in. absolute which would generate 1000 kw. from this steam flow.

In a large power plant 1000 kw. may seem to be too small to consider, but it should be remembered in such cases that this power is obtained at no increase in fuel cost. Assuming such a turbine operated 4000 hours a year at an average load of 750 kw. it would generate 3,000,000 kwh. If this power is worth one cent per kwh. $30,000 would be returned on the investment each year—a sum well worth adding to the net profits after the turbine has paid for its complete cost of installation in little over two years.

FIGURE 6—Chart for estimating power production of low pressure condensing turbines.



"Tops" and "bottoms" provide interesting material for the power plant engineer to use in studying his plant. In the one case, superposed turbines mean new boilers with their auxiliaries and improved feedwater treating equipment, but no change in the condensing equipment. Low pressure condensing turbines mean condensing equipment but no change in the boilers or their auxiliaries. Either type of turbine, properly applied is capable of large savings which will be reflected as increased profits.

Lynn Discussion . . . . . .

(*Continued from page 53*)

types, especially those on electric welders, are glass insulated.

Due to its high temperature qualities, its space factor, its thermal conductivity, we feel that glass insulated electrical rotating equipment may safely be very much reduced in size. One manufacturer has actually reduced his 7½ horsepower totally enclosed motor one-third in size and one-third in weight. From a technical standpoint I just do not know how proper this is, because it is a great reduction. However, this manufacturer is now in production on these motors, they have been used now for over a year, and are now giving satisfaction.

D. M. Petty: The subject, to my mind, is very fundamental and I am afraid that we in the Association have gotten away from fundamentals a little too far, and have dealt a little too much in individual problems and so-called practical problems. I think it would be well for all of us who still profess to be engineers, to be interested in the science of insulation and in the science of the application of insulation.

To me, one of the big problems in the steel industry today, and from an electrical standpoint, probably the largest problem, is what should we do with our high voltage (6600–2300) apparatus which is now twenty and thirty years old. There is a very distinct advantage, to my mind, in calling in the insulation engineers and see what they can offer in the line of new insulation that is thinner thereby permitting a greater cross section of copper. Many motors and generators need this greater copper to carry present overloads.

To my mind one of the hardest parts of this problem is to determine the useful life of insulation on any piece of electrical machinery. What can we do, not only to increase the useful life of its insulation as it now stands, but how can we determine just when to take that motor or generator out of service and re-wind it without letting it fail in service. When a plant has a full order book the loss of production due to an unexpected shutdown is probably a lot more serious than the cost of re-winding a motor. Therefore, we do need some very definite advice and help from the motor and generator designer and insulation manufacturer to tell us how we can determine when we should shut down our high

voltage main drive motors and re-wind them on a pre-arranged schedule rather than wait for a failure.

If we know that we are going to do the job we can provide all the necessary material and equipment and arrange the schedule for minimum interference with operation and the re-winding can be done not only in the shortest length of time, but with the least cost. I feel that this meeting tonight on this general subject of insulation improvement and trends is a meeting that ought to be followed up in the next few years with additional meetings each year on the same general subject, bringing up for discussion the various phases of the problem such as the design of insulation, its manufacture, and also methods of determining the condition of insulation without taking the motor or generator out of service.

I made a note of one item that I did want to bring out in particular. Mr. Lynn mentioned one thing which was rather of interest to me and I hope, if he can, that he will expand on that thought just a little further He mentioned something about designing motors to present standards. The iron and steel industry has been notorious, in the minds of many of the electrical manufacturing and designing engineers, in paying little attention to the so-called standards. If something is good for 80 degrees we want to know why it isn't good for 100 degrees, so that if there are any contemplated increases in standards we would like to know about it.

To my mind, that is a very interesting point, and while we are not so much interested in the reduction in frame sizes or increasing horsepower ratings per given size of frame, we are interested in standards of all kinds.

C. LYNN: Mr. Schnure's hope, that an impregnation for cotton insulation that would increase its useful life would be developed by research physicists and chemists, will never be realized as cotton itself is organic and as such deteriorates both with age and temperature; the higher the temperature, the greater the deterioration in a given time. All useful impregnations to date are also of organic nature and as such have this same failing. The only practical way to obtain longer life is to use materials for insulation, such as mica and glass, that do not deteriorate as quickly as organic material.

The aging of spare insulated coils is, as Mr. Schnure states, quite a problem, and all the manufacturers are working with the thought of developing a suitable and cheap covering that will protect insulation from oxidation while such insulated coils are being stored as spares.

The question is asked by Mr. Van Artsdalen as to which is the most satisfactory impregnation on the new insulation. To date there are no satisfactory impregnations for glass insulation that will extend the limits of temperature for this insulation to the high degree that glass itself extends them. In other words, if glass insulation is impregnated with present day organic impregnations, the temperature limitations are those of the organic material and not of the glass insulation. It may be that some impregnation may in the future be developed that will parallel the higher temperature limits of glass insulation itself.

The points brought up by Mr. Fister are somewhat along the lines of those mentioned by Messrs. Schnure and Van Artsdalen, and the only recommendations that I can make to his question as to the best treatment to apply to windings on machines to reduce the deterioration, would be to use a varnish treatment of coils themselves. We have found that by copious use of varnish treatment crevices are sealed against the entrance of dirt and other harmful effects on insulation. This gives the maximum insurance against failure of insulation.

I believe Mr. Stewart's questions in regard to the temperature limits of impregnations in respect to the temperature limit of glass and other class B insulations have been answered by the above discussion.

Glass itself is quite resistant to various forms of atmospheric fumes and gases and since it is non-hygroscopic, it will not absorb air or water vapors. Since glass insulation, except for low voltages, is not used as ground insulation, the effect of these fumes is still detrimental to other high temperature insulations, such as mica. However, with an outer covering of glass more protection will be afforded to these other higher temperature insulations. This answers Mr. Coffin's questions.

Mr. Nichols' statement in regard to the water submersion test of ABA insulated coils and glass insulated coils appears to refute the statement given above. However, without knowing how his two different types of coils were built and treated, it is difficult to analyze the results of these tests. It would appear, however, to me that the glass insulated coil did not have the advantage of impregnation protection that the ABA coil had, and that there remained, in the minute spaces between the fibres of the glass, entrained moisture which gave the lower breakdown voltage experienced in the test. Our tests indicate that with equivalent impregnation the glass insulation will resist breakdown from moisture to a greater extent than other insulations.

Mr. Petty brings up a lot of questions that are of vital interest to designers and operators. It is, of course, difficult to tell prior to actual failure of a machine just when it should be rewound. This same question, of course, enters into discarding of any object which has a limited useful life. The degree at which insulation can be operated approaching failure depends upon the continuity of service demanded from the piece of apparatus. If failure causes very little inconvenience and the damage to the machine itself is not great with actual failure, then a machine can be run to the point of failure before being rewound. Obviously where high degree of reliability and continuity of service is demanded, only a reasonable amount of life should be taken from the insulation and rewinding should be done before actual failure occurs.

Mr. Petty also brings up the question of loading and overloading machines. Obviously, if a machine is always run below the rating for which it was purchased there is very little likelihood of ever getting into trouble but if it operates at overloads for appreciable periods of time, there is the possibility of trouble and premature failure. It may be necessary in many cases to operate electrical machines at overloads even at the expense of reduced life and relatively frequent rewinding. This is a question of economics. Mr. Petty asked that I expand the thought of designing motors to present standards. What I meant by this is that if a 40 degree motor is rewound with higher temperature insulation but you still limit the temperature rise to 40 degrees, you cannot

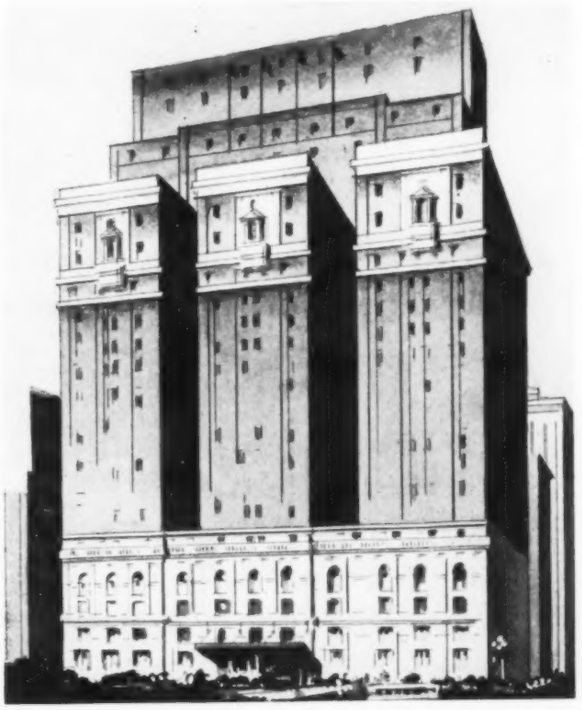
get any more rating out of the motor, assuming that it operated up to a temperature of 40 degrees at its rating. In a motor you have so much space for insulation and so much for copper, and it has been brought out that glass was a spacer in respect to insulation dielectric, whereas mica is not a spacer but a true dielectric. Any material that has threads in it as asbestos, cotton or glass is an insulation spacer and gets its insulation dielectric from any insulating compounds with which you impregnate it. Mica has dielectric strength, and that is why I said mica was going to still be the insulation in the future and the glass will not displace it as a dielectric insulation. However, glass does have a good field in that we can use it as a backing for mica and not have any material in the insulation that will deteriorate with higher temperature operation. Even if shellac or other binders are used to make the mica and glass adhere, their disappearance due to high temperature operation will not impair the insulation on the coil in any manner.

In this same connection we had a motor originally sold with class A insulation for 1000 hp. which we rewound using a glass insulation and when rebuilt it had a rating of 1400 hp. If I did not qualify the statement further, you would think that glass insulation was wonderful. However, in order to get this increase of 40 per cent out of this particular motor we had to go to higher temperatures. The use of mica and glass permitted us to go to class B temperatures and raise the horsepower rating of the motor. Obviously, this could not have been done with the original windings which had class A insulation. We could get smaller machines if we could get iron that would carry more flux. We can get iron that will carry up to 10 per cent more flux, but this special iron costs five or ten times as much as the laminated sheet steel that we use at present, so that its use is commercially prohibited.

Mr. Turner wants to know to what extent new glass insulation has been applied to small electrical apparatus such as contactor coils, etc. Since glass insulation costs more than cotton insulation, its use is obviously from a commercial standpoint limited to those applications where the higher cost is justified by space limitations or other operating requirements. As production increases, cost will be reduced. In terms of the large amount of contactor coils, small motor windings, magnets and solenoids that are produced annually, the total amount of these parts that are glass insulated would be a relatively small per cent at the present time. We have built two 5000 hp. motors for reversing mill service with glass and mica insulated armature coils and we we are applying the glass insulation on some other equipment now being built. Manufacturers of all types of electrical machinery recommend the opportunity for new and improved types of insulation, but obviously they must proceed with caution and that is what is being done in connection with the newly developed glass insulation.

Mr. Hagner has presented the glass manufacturers' side of this new development and I want to thank him for his contribution to my paper in this respect.

Make your plans now to attend the



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of the

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"Shutdowns on our Knitting machines due to fuses blowing are very rare since using BUSS *Super-Lag* FUSES . . ."

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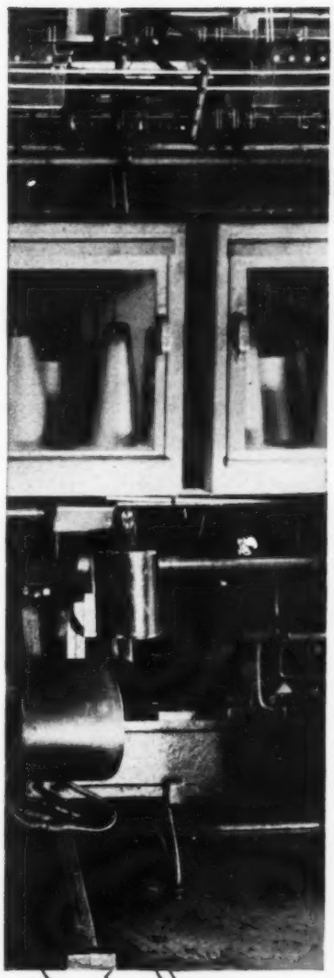
Oakbrook Hosiery Mills,
Reading, Pa.

Here was **MR. HOLZMAN'S PROBLEM** *as he relates it:*

"Operators on our knitting machines inch the machines seven or eight times in starting before running smoothly.

"Because of this the fuses we were using blew very frequently causing annoyance, confusion and high production costs.

"Since using BUSS Super-Lag Fuses shutdowns due to this cause are very rare. The fact is without BUSS fuses we would have difficulty operating at all."



DON'T BURDEN YOUR PLANT WITH SHUTDOWNS—THAT CAN BE AVOIDED

For years many executives have accepted the idea that shutdowns caused by the needless opening of protective devices were a necessary evil, a penalty imposed on them to obtain safe electrical protection.

Since in dealing with useless shutdowns we are dealing with money waste, isn't it a matter of executive importance to determine how to minimize this evil—or eliminate it entirely?

Experience teaches that needless opening of protective devices can generally be traced to one of two causes:

a. Heating from poor contact which raises the temperature of the device and causes it to open prematurely.

b. Harmless overloads that open devices whose time-lag is not sufficient to permit the overloads to clear themselves.

How BUSS *Super-Lag* FUSES can help you

In BUSS Super-Lag fuses the chance of poor contact causing the fuse to blow is minimized by a patent Fuse-Case design that practically eliminates any chance of poor contact developing either from faulty renewal or while the fuse is in use.

Harmless overloads are prevented from blowing BUSS Super-Lag fuses by the Super-Lag development—"lag-plates" attached to the fuse-link.

These "lag-plates" give the fuse a time-lag sufficient to permit most harmless overloads to clear themselves. Harmless overloads are those caused by simultaneous starting of two or more motors, momentary slowing down or jamming of machines, and the like.

By eliminating "false-alarm" blows that have nothing whatever to do with safe protection, BUSS fuses eliminate the annoyance and expense of numerous senseless shutdowns heretofore suffered by many users of ordinary fuses.

Get the facts for yourself

Your name and address will bring a free copy of the book "How to Select Renewable Fuses."

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Executives interested in plant maintenance or operation will find it of refreshing interest.

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WHY BUSS FUSES DON'T BLOW NEEDLESSLY
10 FEATURES in the design of the FUSE-CASE help make it possible..
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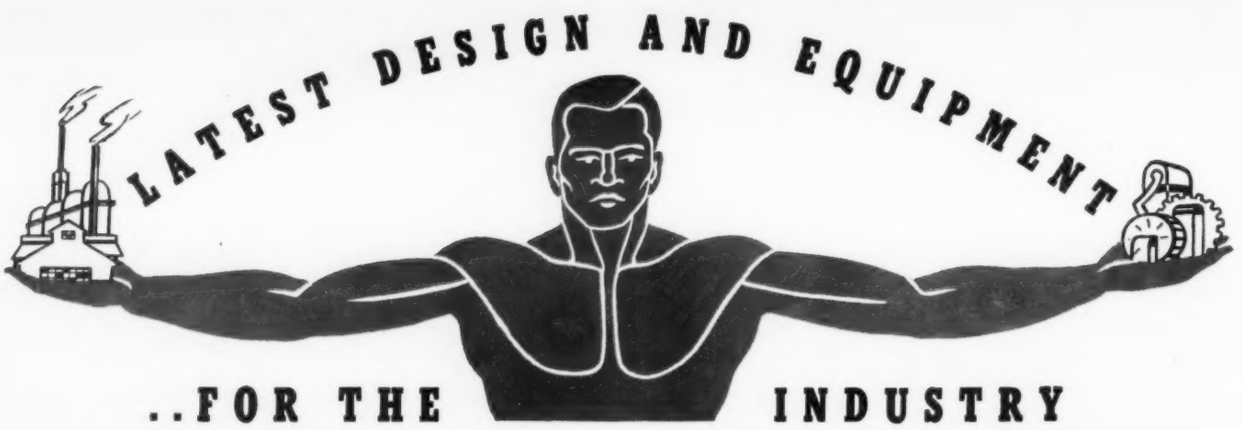


HIGHER SPEEDS FOR TANDEM MILL

▲ Weirton Steel Company has ordered electric drive equipment designed to operate a four-stand tandem cold reduction strip mill at rolling speeds higher than any now in use for this type of mill. This equipment, which will be used in a relocated mill at Weirton, West Virginia, has been purchased from the Westinghouse Electric and Manufacturing Company.

The order includes four mill motors with a combined power output approaching 5,000 horsepower, a 300-horsepower reel motor, a 5,000-kw. main motor-generator set, and a 650-kw. auxiliary motor-generator set.

About half of the main motors will be built to run at the higher desired operating speed of the rolls to which they will be directly connected, thus eliminating intervening gears. Delivery of the electrical equipment will be completed before the end of the year.

LUKENS TO MAKE LEAD-BEARING STEEL

▲ Lukens Steel Company, Coatesville, Pennsylvania, one of the largest producers of steel plates, has just been licensed to produce lead-bearing steels under the Inland Steel Company's Ledloy patents. This provides another source to meet the rapidly growing demands for leaded steels in all kinds of machining operations.

Ledloy, which is produced by the open-hearth process, combines all the desirable properties of open-hearth steel with the free-cutting properties which permit from 50 to 200 per cent higher machining speeds. The lead content which by definition is about .25 per cent serves the further advantage of lubricating the steel and lengthening tool life from 200 to 300 per cent. The addition of lead has no measurable effect upon the physical or heat-treating qualities of steel in any analysis, except, perhaps, for a slight reduction in grain size. Until the Inland process was developed, it was always believed that lead could not be used as an alloying element. Both hot-rolled and cold-finished stocks of this material are available.

CONNORS ADDS ELECTRIC FURNACE

▲ Connors Steel Company, Birmingham, Alabama, has installed an electric furnace to supply its own billets, at a cost of approximately $100,000. The new furnace, the first of its kind in the Birmingham area, is expected to greatly increase the range and production capacity of that plant.

NEW DESIGN OF FLUE GAS ANALYZER

▲ In line with the modern trend in the design of industrial products toward streamlining and the use of plastic material, the Hays Corporation announces a new automatic flue gas analyzer known as "Orsatomat". The greatest change is in the tilting analyzing unit which is now composed of a transparent plastic instead of hard rubber as formerly. The new unit is smaller, lighter in weight and more compact. It is housed in a newly designed, pressed steel case along with a draft measuring and indicating unit. Both analyzing and indicating units are removable. If desired a flue gas thermometer may also be had to fit inside the case.

This analyzer employs the principle of volumetric measurement and chemical absorption. The measuring and absorption of carbon dioxide is done automatically through an ingenious use of mercury. All that the operator needs to do to obtain an accurate analysis of a sample of combustion gas is to pull out a small rod that protrudes from the side of the case, aspirate the gas into the unit by means of a rubber bulb and push in the rod, and the percentage of carbon dioxide is instantly indicated on a dial at the front of the case.

As the rod is pushed in it tilts the pivoted unit causing a column of mercury to flow by gravity to push the trapped gas sample into the absorption chamber (a steel-wool packed compartment freshly flushed with absorbing chemical) where the carbon dioxide is instantly absorbed. This

absorption causes the sample to shrink creating a vacuum which is effective on a sensitive metallic bellows connected to the dial pointer. The entire process requires about one-half minute. This analyzer is available with the draft measuring unit and flue gas thermometer, and it is also available for simply analyzing carbon dioxide. A two-unit model may also be obtained for carbon dioxide and oxygen, and a special model for use in testing the efficiency of internal combustion engines.

NEW CIRCUIT BREAKER OF WIDE APPLICATION

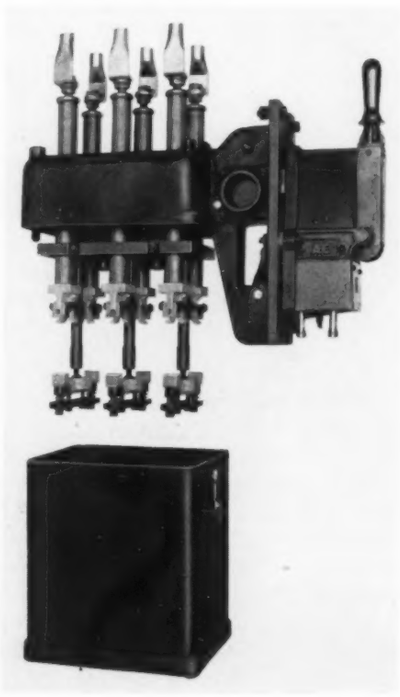
▲ A new switchboard type oil circuit breaker, capable of wide application to central station and industrial service is announced by the Boston works of Allis-Chalmers Manufacturing Company.

This 50,000 kva. interrupting rating breaker is of particular interest because the three poles are arranged one behind the other as viewed from the front or operating end of the breaker. The arrangement of the bushings so obtained eliminates the necessity of crossing the leads in certain applications of open and enclosed type switchboards. For the same reason, it is adaptable for replacing obsolete breakers of the same arrangement, as existing bus and feeder connections may be retained.

The circuit breaker is equipped with large butt-type arcing contacts. The main current carrying contacts, silver-plated, are of the wedge and finger type for 600 amperes and wedge and laminated brush type for 1200 and 2000 amperes. Other features include: bakelain bushings, enclosed low inertia high speed mechanism, and vents to permit escape of gases incident to interruption.

Furnished for 600 amperes at 15 kv., 1200 amperes at 7.5 kv. and 2000 amperes at 5 kv., it is arranged for flat surface mounting or for mounting in cells, switchhouses, cubicles, metal clad switching equipment and safety enclosed switchboards.

Poles in the new breaker are arranged one behind the other as viewed from the front end.

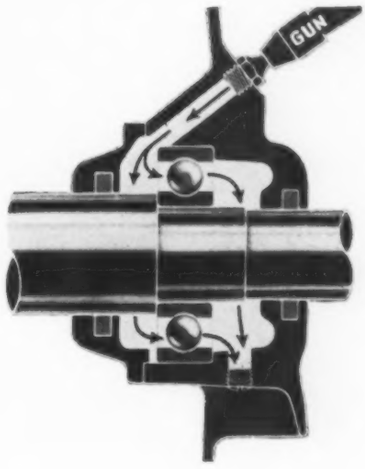


YOUNGSTOWN EXPANDS PIPE CAPACITY

▲ Youngstown Sheet and Tube Company will shortly begin construction of a new butt-weld pipe unit at its Campbell, Ohio, plant. The new unit will be of the Fretz-Moon type and will make pipe in diameters ranging from ½ in. to 3 in. The 10-inch skelp mill at the plant will be equipped with coilers to supply the required raw material. It is believed the cost of the mill will be about $250,000.

IMPROVED METHOD OF MOTOR LUBRICATION

▲ A new method of lubrication of electrical motors has been devised by the U. S. Electrical Motors, Inc. This new system is known as "Lubriflush" and is a distinct departure from the system that has been in vogue for many years. In the orthodox design of bearing chambers, no provision is made for the escape of old lubricant. When new lubricant is applied to the bearings it mixes with the old grease. However, in the "Lubriflush" method the lubricant is injected to the inner side of the bearing with a pressure gun, through a duct leading from the outside of the motor. A drain is placed on the opposite side of the bearing underneath. As new lubricant is injected, the old lubricant is forced out of the bearing and before the new lubricant reaches the drain exit it must first flush the entire bearing and chamber.



The bearing chamber is designed to allow old lubricant to be forced out by the new grease.

This new design eliminates the evil results of sludgy, worn-out lubricant. It provides a method of ejecting the old devitalized grease so that the bearing is replenished with clean lubricant throughout its retaining chamber. The grease fitting and drain plug are easily accessible.

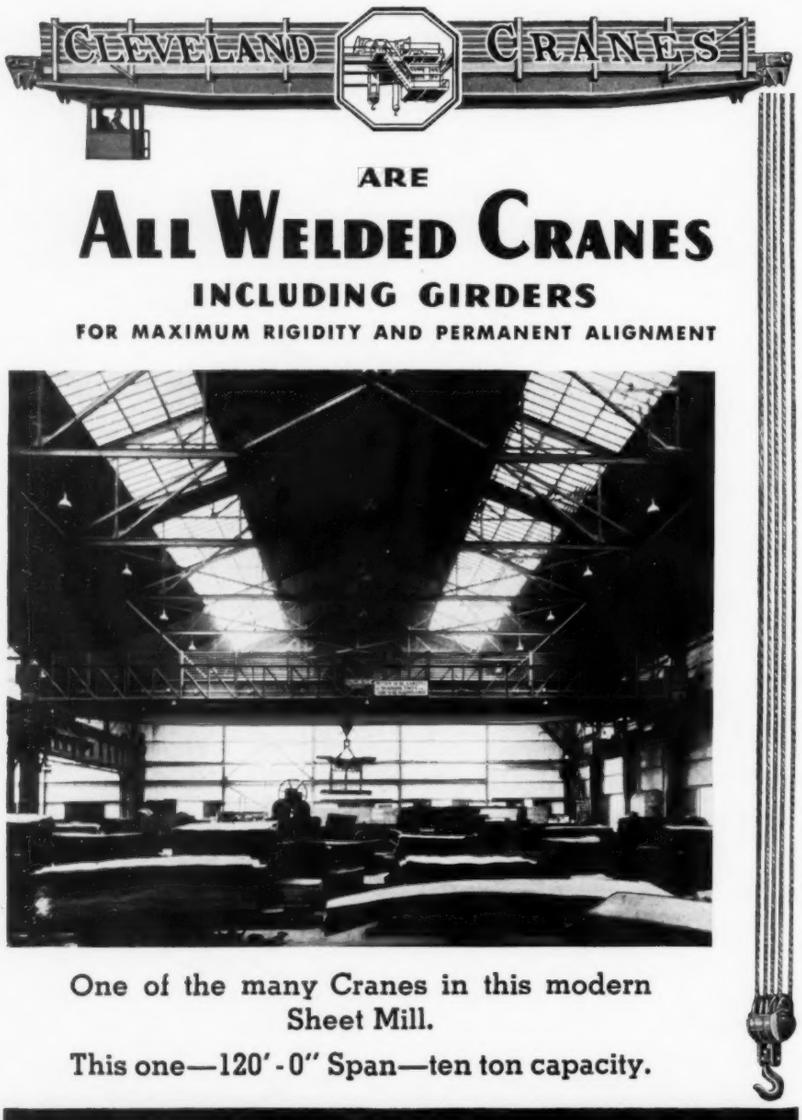
FOREIGN PRODUCERS PURCHASE NEW MILLS

▲ Tata Iron and Steel Company, Jamshedpur, India, has purchased two three-high sheet mills and accessory equipment from the Lewis Foundry and Machine Division of the Blaw-Knox Company. Part of an expansion program, these units will increase the Indian firm's sheet producing capacity by more than 100,000 tons annually. The mills will take sheet bar of ⅜ in. thickness and reduce it to about 1/16 in., or 16 gauge, in two single and three matching (paired) passes. The mills will be of the jump type, 20 by 33 by 52 in., with only the bottom roll power

driven. The roll speed will be about 30 rpm. All three rolls will have three-station water sprays over their bodies so that the screw operator can better control the shape of the bar. The middle roll is equipped with an adjustment to facilitate lateral alignment.

Each mill will be equipped with the recently improved automatic roller and catcher tables, each controlled by a seated operator. The screwdown will be hand-operated, and consists of spanner wheels and operating lever. The screw operator has all water valves conveniently located on his side of the mill so that shape can be controlled by the turning of a valve; in the case of table operators, routine control is obtained by footswitch with finger-tip emergency, and adjustments of tables to mill setup are done by hand wheels easily accessible from the operator's position. New mechanical features will enable the removing and replacing of the middle roll in less than ten minutes, while all three rolls can be changed in less than an hour. It is not necessary to remove spindles, spindle carrier, or drags in order to change the bottom roll. There are no bolts to break off and no heavy clamp plates bolted on the outside face of the housing for retaining the roll chocks.

Forges de Leval Aulnoye, a steel plant located in the northern part of France, has also purchased a three high sheet mill from this Blaw-Knox subsidiary. In accordance with a recent arrangement covering the manufacture and sale of certain Blaw-Knox products for European markets, Detombay of Charleroi, Belgium, will assist in producing this mill. Lewis Foundry will do the engineering and provide certain parts and all of the rolls. The unit will be a balanced type mill, with two of its three rolls power driven, and equipped with automatic roller and catcher tables; automatic screwdown; new shape control water sprays; and special mechanical features to permit rapid roll changing.


CLEVELAND CRANES
ARE
ALL WELDED CRANES
INCLUDING GIRDERS
FOR MAXIMUM RIGIDITY AND PERMANENT ALIGNMENT
One of the many Cranes in this modern Sheet Mill.
This one—120'-0" Span—ten ton capacity.
THE CLEVELAND CRANE & ENGINEERING CO.
1131 Depot St.
WICKLIFFE, OHIO.
ALSO BUILDERS OF CLEVELAND TRAMRAIL MATERIALS HANDLING EQUIPMENT
NEW YORK DETROIT PITTSBURGH CHICAGO

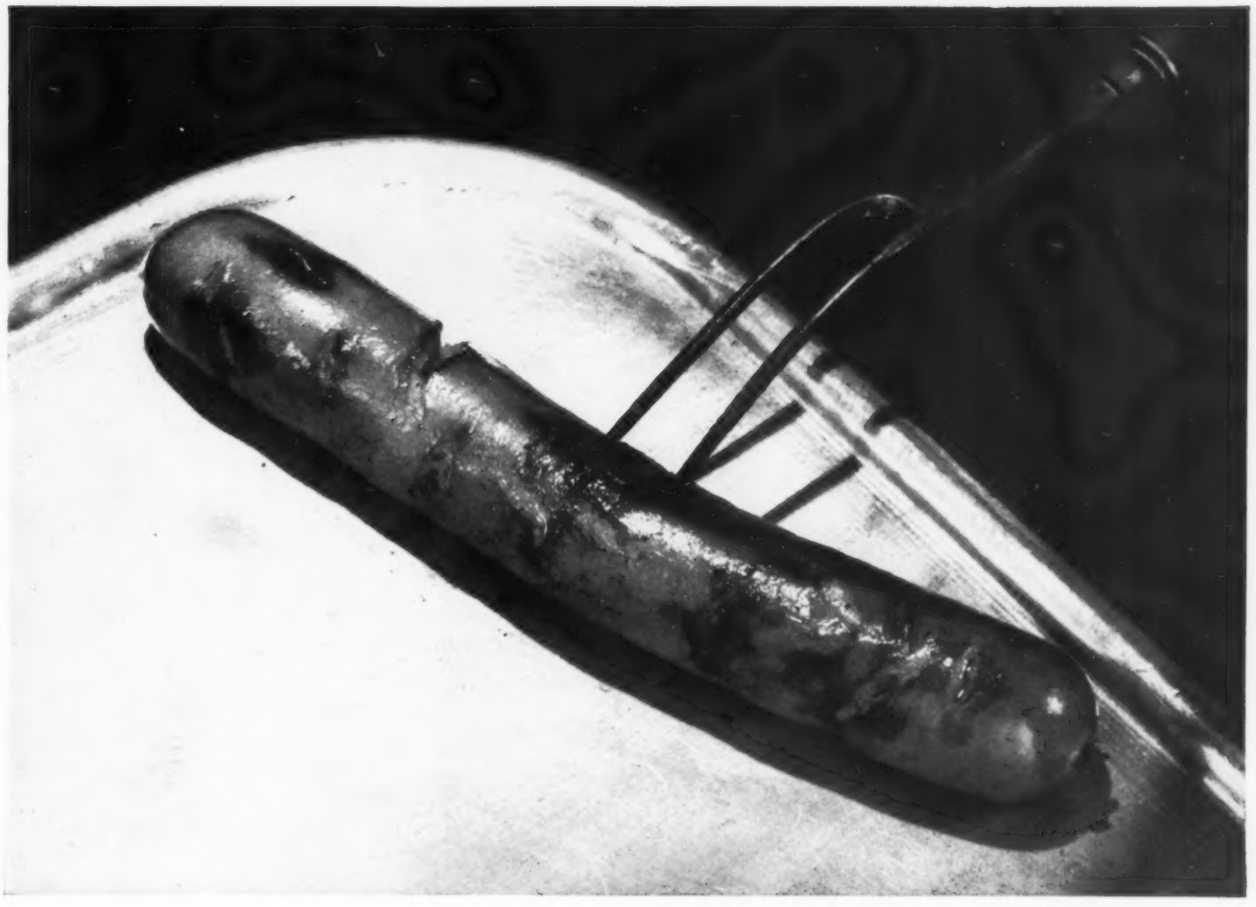
IMPROVED SIGNALS FOR PLANT USE

▲ A more efficient signal system with lower installation and maintenance cost is the announced aim of the Benjamin Electric Manufacturing Company in introducing a completely new improved line of howlers for industrial signal use. The three outstanding improvements have been made in tone, volume, and a simplified assembly which permits the operating unit to be more quickly installed and serviced.

Greater sound penetration is secured in the signal system by increasing the sound volume of the unit by 100 per cent, and engineering a new distinctive tone that gives the signal greater audibility. This greater signal efficiency is secured without requiring any increase in current consumption. The improved signal is obtained through a completely new control of tone and pitch combined with an improved design for sound amplification. New types of form wound coils further contribute to the improved tone signal.

The installation is greatly simplified by a simple turning of a threaded

(*Please turn to page 66*)



Beware of "HOT DOG" INSULATION

When the skin cracks open it's high time to turn off the heat. Mr. Hot Dog is done! Cracks in the insulation of your control, lighting or power wiring show that heat has been at work, too, and as in the case of the hot dog, the cracks indicate that the wire is definitely "all done."

But just because you have heat-exposed installations don't get the idea that you have to put up with frequent breakdowns and expensive replacement. Rockbestos is built to stand up in just such tough locations. It takes the heat without flowing, drying out or cracking, and you can run it in high temperature areas or as close to boilers, furnaces, steam lines or other heat-producers as necessity demands. It is also fireproof and practically immune to rotting, blooming and swelling so often caused by oil, grease and corrosive fumes because of the indestructible character of its insulation. Try it the next time one of your heat-dried circuits calls out the trouble crew.

We manufacture wires, cables and cords for severe conditions exclusively. Constructions range from fine magnet wire to 2,500,000 C.M. cable for service voltages up to 8000. All of them bring you the "Ten Tested Rockbestos Values." Write for a catalog and ask for samples. Rockbestos Products Corporation, 930 Nicoll St., New Haven, Conn.

TEN TESTED ROCKBESTOS VALUES

1. Heatproof
2. Fireproof
3. Permanent
4. Lower maintenance cost
5. Resists heat and vibration
6. Saves work
7. Oil and Greaseproof
8. High overload capacity
9. Permanently flexible
10. Greater carrying capacity

Also refer to Electrical World Buyer's Reference

ring which attaches or detaches the howler from its base. The entire assembly plugs into the base socket in much the same way as any ordinary household appliance plugs into a wall outlet. This plug-in feature assures line replacements to be made with a minimum of signal service interruption. The separable construction facilitates inspection and service work. An essential factor to this new construction is a specially designed threaded ring which seals the operating unit against dust and moisture.

WEIRTON OPERATES STRUCTURAL MILL

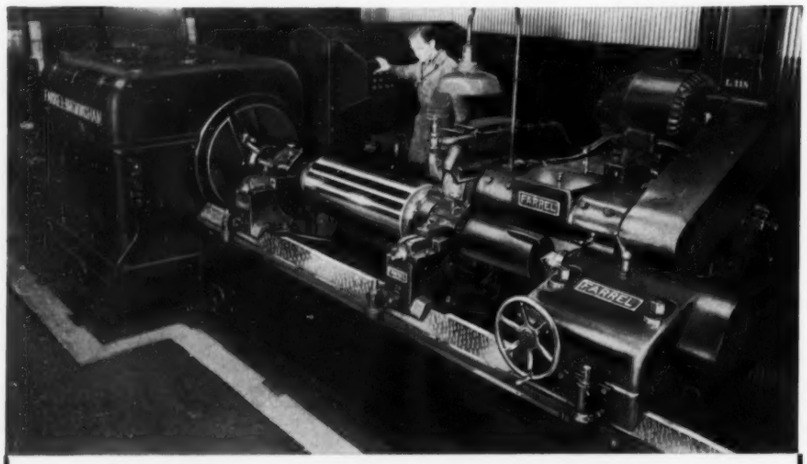
▲ Weirton Steel Company's new $5,000,000 structural mill at Weirton, West Virginia, capable of rolling 50,000 tons of finished steel per month is ready for capacity operation. Equipped to produce structural steel in the range of sections and sizes in greatest demand, the new mill is of the most advanced design and has been arranged to make possible maximum flexibility of operation. Orders calling for different sections and sizes are permitted to follow each other through the rolls with the least loss of time in structural steel mill practice.

In addition to the products rolled before expansion, the new mill will produce a wide range of structural products, including flange beams up to 24 in. depth, all gauges of sheet and Z-piling, and a complete range of H-beams, I-beams, angles, channels, bulb angles and special sections.

Prior to construction of the mill the structural facilities at Weirton consisted of a 23-in. mill and auxiliary equipment. These facilities have been retained but are now supplemented by new furnaces, a new two-high reversing 35-in. blooming mill, two complete trains of 29-in. structural mill and universal roll stands together with hot beds and auxiliary equipment. To house the new equipment it was necessary to increase the storage and material handling space of the mill almost 60,000 square feet. Ample rail facilities were provided for shipments to consumers, to other departments of the company, and to the structural warehouse.

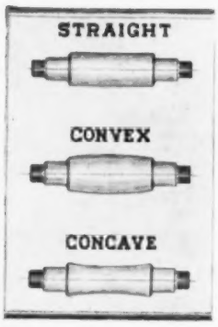
Speed and flexibility of operation have been obtained by providing motor drives with an unusually wide range of speeds and also by provisions which make it possible to connect roll stands mechanically and operate them together with synchronized motors.

Normal operating delays have been greatly reduced by designing the mill so that entire stands of rolls may be removed from roll trains on conclusion of a rolling order and immediately replaced with other stands in which the rolls have already been adjusted for a run of different material.



FARREL ROLL GRINDERS

Assure Maximum Output of Precision-Finished Rolls



The Farrel Automatic Crowning and Concaving Attachment automatically controls roll shape. Straight, convex or concave contours are ground exactly symmetrical on both halves of the roll.

♦

For full information send for copy of Bulletin No. 111.

Continuous operation of a machine means maximum output. The design and construction of the Farrel Heavy Duty Roll Grinder permit continuity of operation . . . . . obviate the necessity for frequent stops to make adjustments and to correct defects attributable to dependence on the operator's skill. Maximum output of rolls ground to close accuracy and with fine finish is thus obtained.

Automatic and semi-automatic features permit close control of roll accuracy and finish to meet predetermined standards. Rolls of any material can be ground with extreme precision and with any finish which can be obtained with wheels now available. Heavy roughing or fine finishing can be done equally well. Straight, convex or concave contours are ground to exact symmetry and accuracy. A perfect surface free from marks of any kind is produced.

When rolls are ground with the accuracy and finish obtained in a Farrel Heavy Duty Roll Grinder rolled metal strip and sheet with better quality surface and more accurate gauge is produced in the mill.

FARREL

FARREL-BIRMINGHAM COMPANY, Inc.
ANSONIA, CONN.
New York • Buffalo • Pittsburgh • Akron • Chicago • Los Angeles

NEW LITERATURE

▲ Burt Manufacturing Company has on hand folders covering the construction of their "Monovent Continuous Ridge Ventilators". Although this is not a new product, improvements are being announced which include several types of damper operators, both manual and motor operated. This folder describes detailed methods of mounting and flash-

ing the ventilator to all types of building constructions.

Persons desiring copies of this booklet should write to the Burt Manufacturing Company, Akron, Ohio.

▲ Robins Conveying Belt Company has issued two new bulletins covering mechanical material handling. The first is known as Bulletin No. 105, and is entitled "Vibrex Screens". Describing specifically the style H and the style J "Vibrex" screens, the book also contains brief descriptions of other Robins products.

The second book, Bulletin No. 106, is entitled "Car and Barge Haulage Systems and Car Retarders". Included in this are designs, specifications, and other pertinent material.

Readers interested in the mechanical handling of materials should write to the Robins Conveying Belt Company, 15 Park Row, New York, New York.

▲ Allis-Chalmers Manufacturing Company, Milwaukee, Wisconsin, has issued the following bulletins:

Bulletin B6012, which describes their latest complete line of vertical lift metal clad switchgear to provide maximum safety with minimum expense for control of generators, motors, incoming lines, feeders, bus tie circuits, etc. This folder covers the advantages, construction details and uses applying to this latest trend in highly developed switchgear. It shows the newest safety features and includes full page dimension sheets and circuit diagrams helpful to the engineer in his station planning.

Bulletin B6011, which describes their "Indoor Cubicle Type Switchgear". This booklet contains new installation views, dimension sheets and wiring diagrams, as well as application and construction data.

Bulletin B6010, describes a-c. and d-c. motors, as well as typical electrical and mechanical variations for special purposes. It includes list prices, dimensions and applications.

▲ Cutler-Hammer, Inc., has issued an interesting booklet entitled "Dust the Destroyer—and How to Avoid His Cost". The book includes a complete series of advertisements used by this company in a campaign to lower costs of production for the industry. Amply illustrated throughout, the book gives a good picture of the damage dust can do to industrial mechanization.

If you would like to obtain a copy of this booklet please write to Cutler-Hammer, Inc., located in Milwaukee, Wisconsin.

▲ De Laval Steam Turbine Company has published a new booklet entitled, "De Laval Worm Gears in Industry". This bulletin illustrates the varied and numerous applications of worm gears in transmitting power from electric motors, water turbines, internal combustion engines, etc., to slow and moderate speed machinery of all kinds. The advantages of the worm gear drive for smooth and silent operation, uniform and positive flow of power, standardization of electric motor speeds, saving in floor space, safety to attendants, and high efficiency are all explained. Specifications are given, and standard forms of such gears are described.

Copies of this brochure may be obtained by addressing the De Laval Steam Turbine Company, Trenton, New Jersey.

REGISTERS DRAFT,
PRESSURE
AND
DIFFERENTIAL
in
SOAKING PITS
ANNEALING FURNACES
OPEN HEARTHS
SLAB MILLS
HAYS "OT" DRAFT RECORDER
Results in a better product because it gives a correct indication of furnace atmospheres. Built husky enough to stand the severest steel mill conditions yet sensitive enough to register accurately in increments of .0025 in. water. Employs the famous Hays Slack Leather Diaphragm—self sealing—not damaged under sudden excess pressures. Two draft values, two pressure values, two differential values, or a combination of any two of these three values may be recorded. Or a temperature recorder may be substituted for one of these values. Send for descriptive literature. Write to 955 Eighth Avenue, Michigan City, Indiana.
The HAYS CORPORATION
SINCE 1907
COMBUSTION INSTRUMENTS AND CONTROL
MICHIGAN CITY, INDIANA, U.S.A.

ITEMS OF INTEREST

Henry R. deHoll has retired from the position of general superintendent of the Indiana Harbor Works of the Inland Steel Company after 26 years of service with the company. He will retain his connection with Inland in a consulting capacity. Mr. deHoll became associated with that company in 1912, first as superintendent of the coke plants, then in charge of blast furnaces and coke plants. He had been general superintendent for the past nine years.

Previous to his association with Inland, Mr. deHoll was with the Tennessee Coal, Iron and Railroad Company at Birmingham, Alabama.

Frederick M. Gillies was appointed general superintendent of the Inland Steel Company's Indiana Harbor Works, succeeding Henry R. deHoll, resigned. Mr. Gillies first went to Inland in 1922 as superintendent of the 100 in. plate mill, and has been in charge of several different divisions of the Indiana Harbor plant. For the past nine years he has served as assistant general superintendent of the plant.

FREDERICK M. GILLIES

Prior to his affiliation with Inland, Mr. Gillies was associated with the Illinois Steel Company at South Chicago, Illinois. He attended Cornell University, majoring in engineering, and was well-known as one of the university's outstanding football players. Continuing his interest in athletics, he has promoted many recreational enterprises for workmen in the Inland mill.

J. H. Miller was made superintendent of the electrical department of the Wisconsin Steel Works of the International Harvester Company, Inc. Mr. Miller was born in Atlanta, Georgia, and

J. H. MILLER

educated at the Georgia School of Technology, from which he was graduated with a degree of bachelor of science. From 1922 to 1929 he was associated with the Georgia Power Company, of Atlanta, as sub-station operator, steam power plant operator, testing engineer, and in investigation of complaints. During 1929 and 1930, Mr. Miller was with the General Electric Company, at Schenectady. In this position he was for eight months engaged in factory testing of motors and control, and for six months was head of induction motor tests.

In 1930 he went to St. Louis for the General Electric Company as a service engineer. The work consisted of the investigation of complaints, installation and maintenance of any electrical apparatus manufactured by the company. He joined the Wisconsin Steel Works where he did drafting and testing work. In 1936 he was appointed assistant electrical engineer. During his service in that capacity the No. 2 merchant mill was electrified and the 32 in. blooming mill, the 21 in. continuous mill, and the sintering plant were built. Mr. Miller succeeds Frank A. Wiley, who recently retired.

Edwin H. Peirce has been appointed superintendent of the rod and wire department at the Portsmouth Works of the Wheeling Steel Corporation. Mr. Peirce was associated with the American Steel and Wire Company at its New England plants as chief metallurgist; superintendent of the New Haven, Connecticut, works; and later superintendent of the South Works at Worcester, Massachusetts.

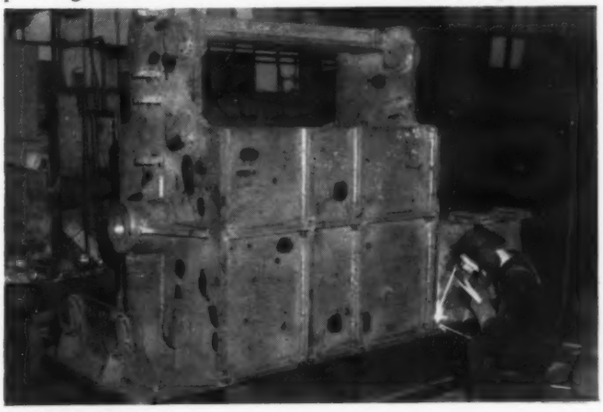
J. Q. Mecum was made assistant works auditor of the Gary Works of the Carnegie-Illinois Steel Corporation. Mr. Mecum began his association with Carnegie-Illinois about a year ago in the methods and procedure department at Pittsburgh. Prior to this he had been employed by the Chicago, Burlington and Quincy Railroad at Galesburg; Wilson and Company, Kansas City; the American Steel Foundries, Hammond; and the Bendix Products Corporation, South Bend.

Philip M. Guba has been appointed eastern sales manager for the Carnegie-Illinois Steel Corporation, with headquarters at New York and Pittsburgh. Mr. Guba will coordinate the sales activities of the company's offices located in the eastern area. He has been affiliated with the Carnegie-Illinois

(*Please turn to page 70*)

WELD IT AND PROFIT

BROKEN PART—Pusher head of a scale breaker. Six welders repaired this broken casting with 400 pounds of "Fleetweld" Electrode. Put it back in service in 8 hours, forestalling prolonged shutdown of entire mill and costly replacement.



NEW PART—Coil box housing being fabricated from flame-cut plate and round bar stock with "Fleetweld 5" Electrode. Strong, rigid, light-weight parts can be built by Lincoln Welding at substantial savings in cost.

WORN PART—Example: Floating ring for hydraulic pump. Face and inside seal built up ¼-inch with "Wearweld" Electrode, increasing pump efficiency, saving a costly replacement and making the part better than new. Hundreds of similar parts can be saved with Lincoln hard-facing.

NEW—*"Shield-Arc"* Welder with Self-Indicating "Job Selector" and Current Control provides *continuous* selection of both TYPE and INTENSITY of arc for top quality and speed on every job. Consult the nearest Lincoln office or mail the coupon for details.

Largest Manufacturers of Arc Welding Equipment in the World

THE LINCOLN ELECTRIC COMPANY

CLEVELAND, OHIO

THE LINCOLN ELECTRIC CO., Dept. Z-635, Cleveland, O.

Send free booklet ☐ "The New *'Shield-Arc'* Welder."
☐ "How to Make it Wear Longer."

Name _____ Position _____

Company _____

Address _____

City _____ State _____

company since 1933, and has been connected with the selling end of the steel industry since 1910.

L. R. Milburn
electrical engineer of Great Lakes Steel Corporation, Ecorse, Michigan, and Chairman of the Detroit Section of the Association of Iron and Steel Engineers, has been elected a fellow in the American Institute of Electrical Engineers.

C. E. Fessler
president of Fessler and Company, Pittsburgh, Pennsylvania, will represent Webster Manufacturing, Inc., in the Pittsburgh area. Mr. Fessler, who has operated for a number of years in that area, also owns and operates a manufacturing concern in Sharon, Pennsylvania.

Q. *HOW HIGH IS UP?*

A. 12 FEET

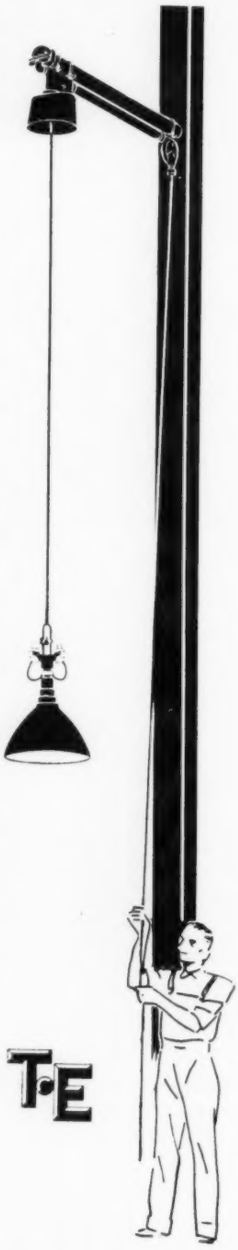
It is standard practice with one large steel mill to specify the installation of a Thompson lamp-lowering hanger with every lighting fixture suspended 12 feet or more above the floor.

Why 12 feet? Simply because beyond that height, servicing a lighting fixture from a ladder or scaffold becomes too hazardous and costly a procedure for this particular Company to permit.

Too high a price for Safety? Not at all, for when one unskilled workman can do a job that formerly required several, and without interruption to anyone otherwise engaged, there's a material saving of money. Actually this Company is getting better lighting, at lower cost, with Safety as a bonus.

If you would like to see how it would work out in your plant, ask a Thompson distributor, or a Thompson engineer to give you the figures.

Thompson Lamp Lowering Hangers, Lamp Shock Absorbers, Suspension Fittings and accessories are sold through leading Electrical Distributors.



T-E

THE THOMPSON ELECTRIC CO.

1101 POWER AVE., N. E. CLEVELAND, OHIO, U. S. A.

Carnegie-Illinois Steel Corporation
recently announced the appointments of the following men in supervisory capacities at the new Irvin Works, Dravosburg, Pennsylvania:

John H. Elliott
as assistant to general superintendent;

William A. Marshall
division superintendent, tin finishing, succeeding Mr. Elliott;

Roy E. Howell
as assistant division superintendent, tin finishing;

Warren W. Scherer
as superintendent of maintenance, succeeding Mr. Marshall;

Arthur M. Krieger
as assistant superintendent of maintenance, succeeding Mr. Scherer.

Obituary

Jacob D. Waddell
69, long prominent in Youngstown, Ohio, district steel and civic circles, died in Niles, Ohio, August 4. Early in Mr. Waddell's career he became associated with James A. Campbell, one of the founders of the Youngstown Sheet and Tube Company. He went to the Warren rolling mill with Mr. Campbell, three years later joining the Falcon Iron and Nail Company at Niles. Two years later he again joined Mr. Campbell with the Mahoning Valley Iron Company, and after five years entered the employ of the American Sheet Steel Company in New York, where he remained four years. In 1906 Mr. Waddell returned to Niles where he was elected secretary and treasurer of the Empire Iron and Steel Company, and when Empire was purchased by Brier Hill Steel Company in 1912, he became general manager of sales for the latter.

In 1916, Mr. Waddell formed the Mahoning Valley Steel Company, serving as president and treasurer until May 1, 1923. The following year, he and his associates purchased the Empire works from Youngstown Sheet and Tube Company, organizing the Waddell Steel Company. He continued as president and treasurer until 1928 when the plant was taken into the newly formed Empire Steel Company, of which he was vice-president and secretary-treasurer until his retirement in 1931.

Iron AND Steel ENGINEER

NOLOGY DEPT.
1010 EMPIRE BLDG.

SEPTEMBER - 1939

PITTSBURGH, PA.

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advertisement appears
e Saturday Evening Post
eptember 9th. "Miles of
es" for every manufac-
and user of Timken
ing Equipped products.

MILES of SMILES

The most contented railroad passenger is the one made most comfortable. Timken Roller Bearings effect comfort for the traveling public such as it never before experienced.

The most contented railroad executive is the one who sees operating costs decline—volume increase. Timken Bearings effect economies, maintain schedules, eliminate hot boxes and old time troubles as never before. This is definitely proven by the highly efficient performance of Timken Roller Bearings, now on most of America's newest streamliners and latest locomotives.

That means Miles of Smiles for everyone.

The soundest dollar for dollar investment the American railroads can make is to equip all rolling stock, old and new—passenger cars, locomotives and freights—with Timken Bearings. Costs come down tremendously—volume shoots up—vastly improved all around operation is the gratifying result. Miles of Smiles for everyone!

NOTICE

Look for the trademark TIMKEN on every bearing, whether buying new equipment, or replacing a Timken Bearing in your automobile, or truck, industrial or farm machinery. That trademark is your assurance of quality.

TIMKEN
RAILWAY ROLLER BEARINGS

THE TIMKEN ROLLER BEARING COMPANY, CANTON, OHIO

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ACES 68-69

The Cutler-Hammer 540 Line*

With New Design Magnetic Blow-out for Instantaneous, Effective Arc-rupturing

GENERAL SPECIFICATIONS OF THE NEW CUTLER-HAMMER 540 LINE OF CONTACTORS *

CUTLER-HAMMER
MOTOR CONTROL
C-H

1. Ratings:

Code Number:	540,	541,	542,	545,	546
Ampere Rating:	100,	150,	300,	600,	1200

2. New design magnetic blow-out for instantaneous, more effective rupturing of arc.

3. Incredibly efficient, heavy long-life arc horns which play a big part in multiplying tip life.

4. New heavy-duty arc shields with carborax inserts opposite the contact tips. Though firmly and solidly set in place, the arc shield *lifts off* for inspection, etc.

5. New, removable contact tips of drop-forged copper.

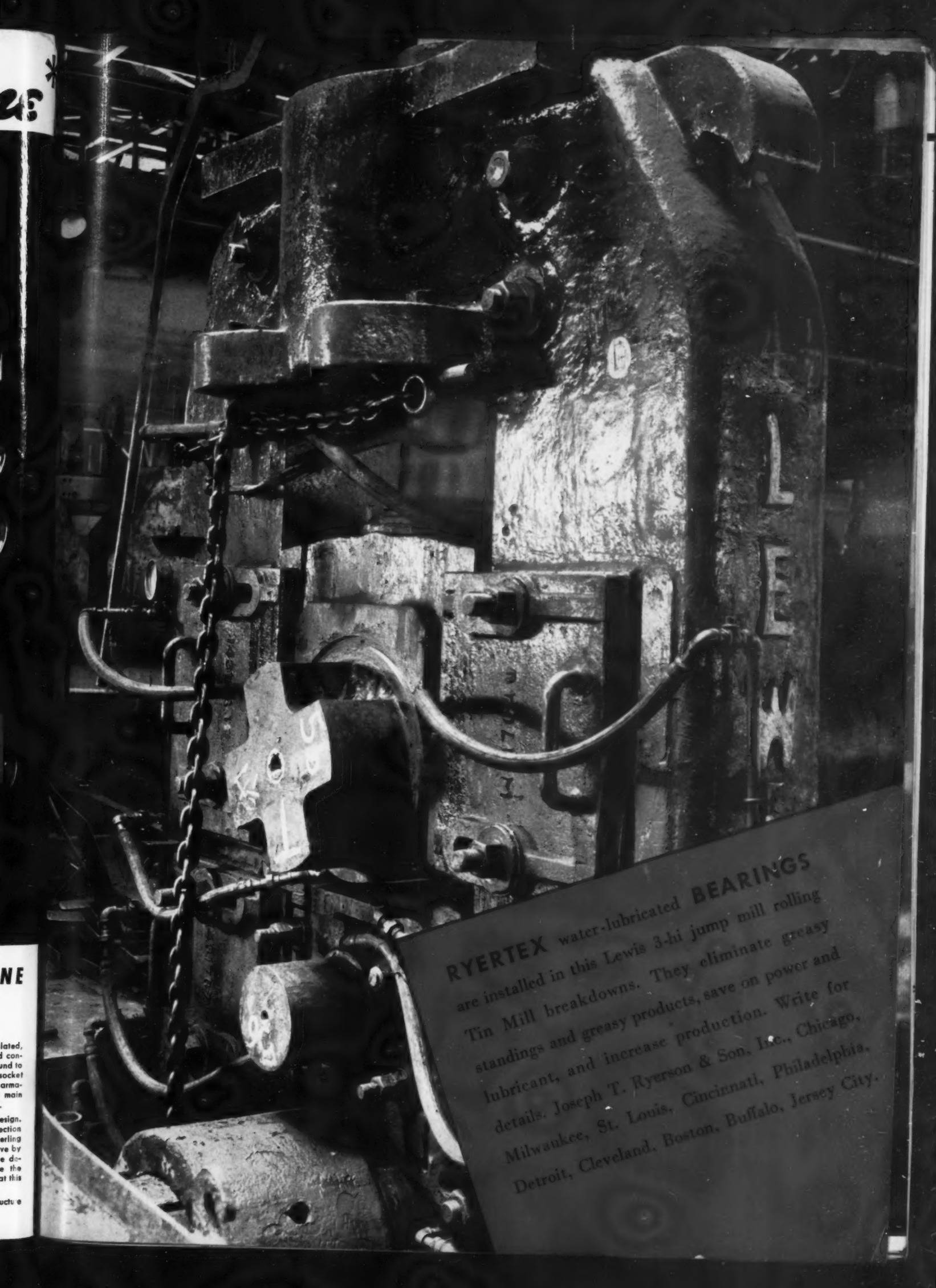
6. Chinawood-oil impregnation makes magnet coil impervious to moisture and dirt. Longer life at high ambient temperatures.

7. Light-weight, strong cast steel frame for still faster action and quicker response to the control.

8. All metal parts of Contactor structure are cadmium plated, non-corrodible, better looking. Main hinge pins and contact lever hinge pins of hardened steel, precision-ground to size, chromium-plated against wear. Plunger and socket fasteners instead of cotter pins. Nitralloy bushings in armature and contact levers to reduce wear. Springs on main contact lever and electrical interlock of stainless steel.

9. A remarkable achievement in electric interlock design. Vertical contacts eliminate possibility of dust-collection and the Monday morning starting troubles. Genuine sterling silver (*not* coin silver) contacts not rendered inoperative by sulphur fumes and oxidation. Double-break for more dependable operation. Bakelite rollers which actuate the mechanism to all intents and purposes eliminate wear at this spot. No current through hinge pins or pivot points.

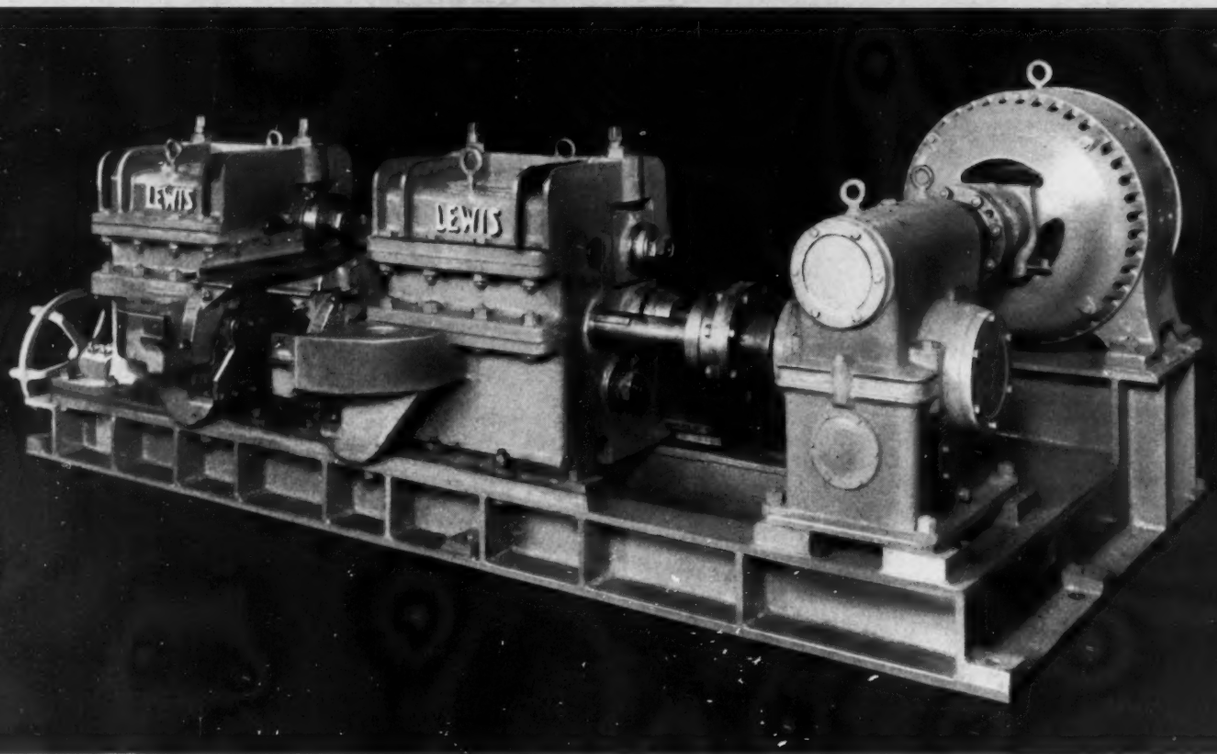
10. Unique accessibility and ease of taking entire structure apart.


RYERTEX water-lubricated BEARINGS
are installed in this Lewis 3-hi jump mill rolling
Tin Mill breakdowns. They eliminate greasy
standings and greasy products, save on power and
lubricant, and increase production. Write for
details. Joseph T. Ryerson & Son, Inc., Chicago,
Milwaukee, St. Louis, Cincinnati, Philadelphia,
Detroit, Cleveland, Boston, Buffalo, Jersey City.

LEWIS

EXPERIENCE · DESIGN · CONSTRUCTION

LOWERS COSTS



A LEWIS Rotary Trimmer and Chopper would quickly earn its place in your manufacturing set-up by thorough and steady work. It can be designed and built to fit the arrangement of any mill and will do its job to the utmost satisfaction of any production man.

Steel mills, and mills rolling aluminum, zinc, copper and brass all know the high standard of quality which distinguishes LEWIS Rolling Mill Machinery.

Machinery for lower production costs is developed at Lewis. Experienced engineers, capable of understanding and solving your problem, are at your disposal.

See the Blaw-Knox Exhibit, Booths 60-61 at the IRON & STEEL EXPOSITION Wm. Penn Hotel PITTSBURGH, PA. Sept. 26-27-28-29 1939

LEWIS FOUNDRY & MACHINE

DIVISION OF BLAW-KNOX CO.

PITTSBURGH, PA.